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New York Meeting of The American Electrochemical Society

The program of the coming New York meeting of the American Electrochemical Society, which is found in full elsewhere in this issue, contains various attractive features to which we wish to call attention. The meeting will be held on Thursday, Friday and Saturday of the third week of October, and will be opened on the evening of Thursday, Oct. 17, by a session at the Chemists' Club. Two lectures by Mr. Acheson and Dr. Kunz on subjects of great general interest have been wisely selected for this first evening session, and it is hoped that everyone who intends to attend the meeting will not miss this session on the first evening. The papers selected for the morning sessions of Friday deal with a variety of timely and important problems of electrometallurgy. A special feature of the Saturday morning meeting will be Dr. Cushman's lecture with demonstrations on the electrochemical theory of the corrosion of iron. In the afternoons a visit to the laboratories of Mr. Thomas Alva Edison, who will personally receive the party, and an excursion to the splendid electrolytic copper refining works at Chrome will certainly prove very alluring. These excursions and the banquet on Friday night, to which ladies are most cordially invited, will, it is hoped, offer the fullest opportunities for social intercourse. The Chemists' Club and Columbia University will be the hosts of the Society at the different sessions, and the meeting will be closed by one of the charming smokers at the Chemists' Club for which its house committee is renowned.

Metallography in Its Practical Applications

Mr. P. Longmuir's paper, read at the Vienna meeting of the Iron and Steel Institute, and given in extract elsewhere in this issue, contains a warning which should be heeded. Neither the Iron and Steel Institute nor the author of that paper can be said to be antagonistic to metallography. Such statements as the following are therefore remarkable: "As a matter of fact no metallographical investigation yet published has been of the least service as a guide to the thermal treatment of high-speed steels." We know that this view is shared by influential, practical steel men in this country. Yet it would be dead wrong to condemn metallography as a whole. Mr. Longmuir's suggestions as to closer intercourse between metallography and practical work, deserve, however, the fullest attention.

The Old and the New Peat Problem

Such enormous amounts of energy, time and money have been spent in the past on endeavors to solve the peat problem, that the practical results which have been attained seem

almost insignificant compared with the efforts made. The last Geological Survey report for 1906, by Mr. Marius R. Campbell, is rather discouraging. "During the year 1906 scarcely any advance was made in the utilization of peat in the United States. About the usual number of companies were organized and glowing prospectuses were issued, but little or nothing was done toward the development of the peat industry in general. Many of the plants that were in operation experimentally in 1905 closed down during the year, so that at the end of 1906 it is probable that there were fewer plants in operation than at the close of 1905." Nevertheless, it would be folly to think that the peat problem was dead. It would be a very lively corpse, indeed, if we consider that those chiefly interested in the development of American peat and swamp lands are just about to organize an American Peat Association. The circular letter which has been sent out to this effect is signed by competent men. Dr. Joseph Hyde Pratt acts as temporary chairman, and the first meeting is to be held at the Jamestown Exposition at the end of October.

* * *

It is not difficult to see why the interest in the peat problem cannot be subdued. The chief reasons are on one side, the enormous extent of peat deposit areas, at present practically worthless, and on the other side the undeniable fact that peat, according to its chemical composition, contains so considerable material values and energy values that their recovery would be highly desirable. But the process of recovery should be cheap, its cost should certainly be considerably less than the amount of the values to be recovered. This is the great difficulty. We might compare the peat problem with a very low-grade ore proposition. As long as high-grade ores are available, low-grade ore propositions are not very attractive. But in recent years we have seen great changes in the attractiveness of such propositions in the case of several metals, both as the result of the scarcity of high-grade ore and of the advances made in the metallurgical art. The peat problem may be considered from the same point of view. There have been considerable changes in recent years in the object aimed at as well as in the means for handling the peat.

* * *

Let us first consider the object. In the old peat problem the object was to convert the peat into fuel suitable for both domestic and steaming purposes, this fuel to be shipped to consumers to compete with coal. In the new peat problem the object is to erect plants in the peat districts themselves for recovery of the values. Two essentially different means are available. One is dry distillation for the production of coke, with recovery of the by-products. The other is using the peat in gas producers for the production of power, also with recovery of by-products. With respect to the by-products, the nitrogen content of the peat is significant, since it is possible to recover it in form of ammonium sulphate; in view of the rapidly increasing importance of the artificial fertilizer industry the fixation of the nitrogen in peat is certainly as attractive a problem as the fixation of atmospheric nitrogen. Concerning the coke produced from dry distillation of peat it is to be pointed out that its quality naturally depends on the com-

position of the raw peat, especially its ash contents, but that its freedom from sulphur should go a long way to make peat coke desirable for metallurgical purposes. Finally, as to the desirability of producing cheap power from peat there can hardly be any disagreement of opinion. If power can be produced cheap enough there will be uses for it even in peat districts which have not yet any industry.

* * *

Secondly, concerning the means of treating peat. All the essential troubles with peat are due to its content of water and to its porosity. Much has been done in the construction of suitable machinery for kneading and treating the peat, so as to mold it and remove a considerable portion of the water. For the dry distillation of peat, the enormous advances which have been made in by-product coke ovens for the dry distillation of coal are of direct importance. Finally, as to the development of power from peat, the whole idea of doing this has become possible only through the development of the modern gas producer and large gas engine. It is evident there are vast possibilities, but it should not be amiss to finally sum up what has been actually achieved.

* * *

According to Mr. Campbell's Geological Survey report, three companies have worked on an experimental scale in 1906 in this country. The Winter Park Electric & Fuel Co., in Orlando, Fla., which uses the Leavitt machine; the Wolverine Peat Fuel Co., near Vicksburg, Mich., which uses the Dolberg machine, and the Lamertine Heat, Light & Power Co., near Vicksburg, Mich., which uses a machine of special type owned by the company. The method of handling the peat is essentially the same in the three plants, namely, digging from bog either by hand or machine; transporting in car or conveying apparatus to mill; disintegrating in mill; molding into bricks, and finally drying by natural exposure until the water is reduced to about 15 or 20 per cent. The Winter Park Electric & Fuel Co. has departed from this practice slightly, as it now dispenses with the molding into bricks, simply dumping the disintegrated peat on the ground and letting it dry in irregular masses, which later are broken with hammers into lumps. This is reported to give excellent satisfaction; it is cheaper, though it requires more space for storage. A very complete plant, that of the International Fuel & Power Co., is nearly ready for operation at a bog located not far from Ogdensburg, N. Y. It is built on a large dredge, and the progress of the peat through the machine from the time it leaves the bog until it is delivered in the form of briquets is entirely automatic. The bog is located on the east side of Black Lake, in a position that makes dredging operation easy. The peat is raised from the bog in bucket conveyors, dropped into the hopper of a disintegrating machine, passed through steam-jacketed pipes to drive off moisture, and then, while hot, is briquetted under immense pressure. The product, according to the claims of the company, contains less than 5 per cent of moisture. Mr. Campbell comments on the prospects of this work as follows: "This plant is very complete and well built, and there seems to be little doubt that briquets can be successfully produced; but whether they can be made cheaply enough to compete with Pennsylvania soft coal at \$3.25 per ton seems to be a question. Doubt-

less, if this operation is successful, it will lead to the utilization of many other peat bogs in Northern New York."

* * *

As to the dry distillation of peat and the use of peat in gas producers, most of the work has been done abroad. A review of a series of papers by two enthusiastic workers in this field, Prof. Frank and Dr. Caro, will be found elsewhere in this issue and contains much interesting information. It appears that dry distillation of peat is commercially successful in one or two German plants. In this country it is hardly to be expected that much will be done in this line until the dry distillation of coal in by-product coke ovens has conquered the whole field that will be surely contributory to it. As to the use of peat in gas producers, Mr. Campbell states that Florida machine peat yields fully as good results as Texas and North Dakota lignites. In comparative tests it was found that 1 pound of Florida peat yields 0.330 electric horsepower, against 0.335, 0.309 and 0.308 for three kinds of North Dakota lignite, and 0.388 and 0.299 for two kinds of Texas lignite. Mr. Campbell says: "Probably the two most important questions yet unsolved are to determine the maximum amount of moisture that can be used in a producer and whether it is necessary to disintegrate the peat and mold it into bricks." It is with respect to these points that the papers of Frank and Caro, reviewed in this issue, give very interesting data on the basis of the results obtained on an experimental scale in a Mond gas plant in England. If the same results can be obtained in general on a large scale the process will be, indeed, very promising. The ammonium sulphate could then hardly be called a by-product, while the power—the excess of power over that needed in the plant itself—would be all "velvet" to the process. The outcome of the operation of the process at the Mont Cenis mine will decide whatever may be doubtful at present.



Technical Education

We have long held to the theorem that the advance in applied science has been the great factor in the material progress of the past fifty years, as the science itself has made inroads on, and upset theological and philosophical thought. The great advance of Germany in commerce and industry has been a steady and persistent application of the principles of physical and chemical science to increasing the efficiency of industrial processes. This is seen in the whole world in the gamut of the little hand-sewing machine used by the Hindoo maid to the great steel rolling mills of Pittsburg. It is the intelligent application of the methods and principles of science that have enabled the complicated organism of modern society to have its rapid growth in multifarious directions. Germany has also been the leader in systematizing the methods for giving the youth the requisite training in the principles of science and the methods of engineering. We Americans cannot but give due tribute to our Teutonic cousins for this pioneer work. The Technische Hochschulen and the Reichsanstalt are concrete evidences of it.



In America we have followed in the same trail, and with our energy and resource have built up a system of technical education that produces excellent results, though still better

things can be expected in the future. To the young engineering students, now entering upon the new year, certain advice can be given. The first is to study general principles, to learn to look at things in a broad way, not merely at details, but to store up a knowledge to comprehend the architecture of their profession. This is the trend of all modern educational methods nowadays. It is less a matter of acquiring knowledge than rather of acquiring the ability to know how to acquire knowledge. One of the most practical reasons for this is that in after life early specialization is useless because some fortuitous circumstance will make the metallurgist an electrical engineer, or the mathematical engineer a salesman. In business as in all life "*l'homme propose, le Dieu dispose.*" We fully agree with the general sentiment in Dr. Baekeland's recent lecture on the dangers of overspecialization, extracts from which will be found on another page of this issue. The allround man, trained in the fundamentals of science, and who knows engineering principles, will never fail to learn the details of his specialty as he works if he has been trained to use his mind independently and broadly. As to the intrinsic value of theories in science, J. J. Thomson's remark, that scientific theories represent a policy, rather than a creed, is highly suggestive. The earlier we learn to understand the wisdom of this remark, the greater will be for us the usefulness of theories.

* * *

Another good bit of advice is to learn, know and practice hygiene. Hard knocks will come to every mother's son in this present evil world. But he who knows hygiene of the body, mind and feelings, can rise superior to fate to take his lot like a brave soldier does death with the exclamation "*kismet.*" And after all this, moral and mental welfare are so much more easily built if the solid foundation of physical health is laid. The example of Gladstone and Roosevelt shows that health is open to every one who will exercise his will. Many a great battle has been lost, many a business wrecked, many a noble poem unwritten for disregard of this cardinal principle. The poorest of us are capable of great things at times, provided our nerves are calm and under control. The lesson of self-control is a hard one, to be learned only by fighting. But bodily health comes thereby, and with it all the rest. It is useless to give too much good advice—the young usually disregard it, but we furthermore counsel young engineering students to study broadly literature, to learn not only correct thinking, but also concise expression of their thoughts. For the time will come when the powers of writing and speaking well and to the point, will turn the balance betwixt mediocrity and eminence. In addition we would say to them, study sociological and industrial conditions; the first to learn to treat workmen from a standpoint of enlightened self-interest, the second to know how to use the forces of nature to produce financial returns, which let us affirm is the criterion of all engineering success. A knowledge of political economy will do this, provided the student is practical and can judge of facts as he sees them, and not in the light of preconceived notions. In conclusion, it may be said, that real wealth is measured by contentment which comes from a task well done. Activity and honesty are the only causes of true human happiness.

American Electrochemical Society.

The twelfth general meeting of the American Electrochemical Society will be held in New York City, Oct. 17, 18, 19 (Thursday, Friday and Saturday of the third week of October).

The meeting will be opened by an evening session on Thursday, Oct. 17. This session, as well as the morning session on Friday, Oct. 18, will be held at the Chemists' Club, 108 West Fifty-fifth Street. The morning session of Oct. 19 will be held in Havemeyer Hall, Columbia University.

Headquarters for registering and information are at the Chemists' Club. Hotel headquarters are at the Hotel Cumberland, Fifty-fourth Street and Broadway.

On Friday afternoon an excursion will be made to the laboratories of Mr. Thomas A. Edison. Mr. Edison will receive the visitors personally. A special car will be provided on the Delaware, Lackawanna & Western Railroad, the train leaving West Twenty-third Street at 2:15. On the evening of Friday a subscription dinner will be held in Liederkrantz Hall. Ladies are specially invited.

On Saturday afternoon an excursion will be made to the new Pennsylvania Railroad power plant at Long Island City, the New York Electrical Testing Laboratories and the large electrolytic copper refinery of the United States Metal Refining Co., at Chrome, N. J.

On the evening of Saturday a smoker will be tendered to the American Electrochemical Society by the Chemists' Club.

During the meetings there will be an exhibition of some novelties of electrochemical products and apparatus at the Chemists' Club.

The program of papers is as follows:

THURSDAY EVENING, at 8 P. M., reception and session at Chemists' Club; 8:40 P. M., illustrated lecture on Diamond and Moissanite; Natural, Artificial and Meteoric, by Dr. George F. Kunz; 9:30 P. M., lecture on Deflocculated Graphite, by Mr. E. G. Acheson, of Niagara Falls, with demonstrations and experiments.

FRIDAY MORNING SESSION, at Chemists' Club, at 9 A. M.—On the Electrothermic Reduction of Iron Ores. Messrs. Albert E. Greene and Frank S. MacGregor.

Discussion of the Electric Furnace Experiments for the Production of Pig iron at the Soo. Dr. J. W. Richards.

Silicon Monoxide and "Monox," a new product of a novel electric furnace. Dr. H. N. Potter.

Discussion of Moissan's Experiments on the Boiling Points of the Metals. Dr. O. P. Watts.

The Electrometallurgy of Zinc. M. Gustave Gin.

A New Application of Chlorine in Metallurgy. Mr. C. E. Baker.

The Heat Conductivity of Carbon. Mr. F. A. J. Fitzgerald. Granular Carbon Resistors. Prof. S. A. Tucker.

SATURDAY MORNING SESSION, at Columbia University, at 9 A. M.—Physico-Chemical Notes on the Aluminates of Soda. Mr. P. B. Sadtler.

Action of Ammonium Persulphates on Metals. Mr. J. W. Turrentine.

Note on the Use of the Capillary Electrometer for Alternating Voltages. Mr. H. G. Floyd.

Electroscopic Determination of Radium in Some Tufa at Hot Springs, Ark. Dr. Herman Schlundt.

Electrolytic Separation of Silver and Copper. Mr. H. W. Gillett.

Electrolytic Determination of Minute Quantities of Copper. Mr. E. E. Free.

Electrolytic Reduction of Nitric Acid. Drs. H. E. Patten and Robinson.

Electrochemical Methods for the Qualitative and Quantitative Determination of Free Silicon in the Presence of Silica,

Silicates, Oxides, Free Carbon and Carborundum. Mr. W. R. Mott.

On the Nature of Electrolytic Conductors. Dr. L. Kahleberg.

The Treatment of Storage Battery Elements Before Putting Them Out of Commission. Prof. O. W. Brown.

Further Study of Concentration Cells. Dr. Hy. S. Carhart.

The Electrolytic Theory of the Corrosion of Iron. Dr. A. S. Cushman (lecture with demonstrations).

Advance copies of the papers of Baker, Carhart, Free, Gin, Mott, Schlundt and Watts are being printed, and will be sent to any member who applies for them by the Secretary, Prof. J. W. Richards, Lehigh University, South Bethlehem, Pa.

Prof. S. A. Tucker, Columbia University, is chairman of the New York committee. Mr. Alois von Isakovics, Monticello, N. Y., is the local secretary.

The Iron and Steel Market.

There is little can be said of September as to distinct new developments; rather, the month has been distinctive in that forces which have been at work for several months have continued and have almost played out, bringing the situation to a point where distinctly new trends must come.

On the one hand, the long wait of buyers, particularly of pig iron, must be nearly over, and a distinct buying movement is measurably within sight. On the other hand, the long period—long for the American iron trade—of high pressure for deliveries of material without corresponding fresh buying is about over. After a run of thirty-two months of production up to the physical limits, the last three or four months without important fresh additions to orders, the machinery of production is just beginning to slow down, and the prospects are that the slowing down will be rapid.

If the simile be permitted, it may be said that from the beginning of 1905 to last May or June the engine has run at full speed, with a good fire under the boiler; in May or June the fire went down, and the boiler pressure began to decrease, but by using a longer and longer cut-off the speed of the engine has been maintained; what steam is left is being taken for the full stroke, and the speed can no longer be maintained.

The Bessemer department at the Duquesne steel works permanently ceased operations about Sept. 1, making way for the eighteen new open-hearth furnaces which are being built. About Oct. 1 the Bessemer department at Homestead will be closed for thirty days or more for repairs. Following this the Edgar Thompson plant will be closed for repairs and improvements. Other producers are to follow a similar course. Many blast furnaces have not been doing well, but have been kept in operation until a fitting time for relining. Some finishing departments have been run at reduced pressure for a month or two, but the steel has found ready use elsewhere.

It appears to be the general view in the trade that the year 1908 will be one of reduced production. This is extremely significant, since, barring the off year of 1904, there has been a rapid and fairly steady increase in production, as to pig iron, of about 2,000,000 tons a year, from a trifle under 14,000,000 tons in 1900, to about 27,000,000 tons in the current year. The years 1905 and 1906 were years of demand, fully up to capacity and showed a production, respectively, of 23,000,000 and 25,300,000 tons. Capacity has been increased, and further erection is in progress, so that were demand sufficient, 29,000,000 or 30,000,000 tons of pig iron could be made in 1908, and if, instead, production falls below 27,000,000 tons, as fully expected, there will be much idle capacity. Such a condition the American iron trade has never before passed through without heavy reductions in prices of all iron and steel products.

Some lines of finished product are sold up better than

others. In structural shapes, plates, and steel bars, the mills claim to be able to run well into next year, without additional buying and merely on contracts already made. In wire products the mills are less well sold up. In merchant pipe, sheet and tin plates, there is relatively little business ahead, and production will be reduced before the end of the year. Tin plate has felt the effects first, as since the closing of some mills for repairs in July, the old pace has not been resumed, and in September a few additional mills were closed.

While the lines of heavy tonnage, including rails, shapes, plates and merchant bars will undoubtedly be held as to price, even though there is a great decrease in demand, price weaknesses have already begun to develop in other lines. The shafting market has been very irregular for two months. Light plates have weakened within the past month. Base prices on merchant pipe are claimed to be maintained, but the premiums for early delivery have totally disappeared. The advance of a dollar a ton in wire products made Sept. 3 is not being maintained. Billets have declined, and of course pig iron continues the decline inaugurated in May.

PIG IRON.

Striking an average of all districts and all grades, pig iron has declined at least a dollar a ton during the month. Transactions have been very light, buyers feeling certain that still lower prices are in prospect, and delaying to the last possible moment. This has resulted in somewhat more extensive buying of small lots for prompt delivery. It is barely possible that the waiting game may be played too long, permitting a temporary spurt in activity to stiffen prices again, but this seems improbable.

Southern No. 2 foundry is openly quoted at \$18, Birmingham, and can be had for less. For the first half of next year, \$17 is openly quoted, while several months ago when the market for next year opened, sales were made at \$18.50. The decline, therefore, is much more than the disappearance of premiums for early delivery. In the North, foundry pig iron has declined in all markets and can now be bought for \$20, f. o. b. certain furnaces, or a shade less. A sale of 500 tons was made about Sept. 23, delivery guaranteed during September, at not over \$20.60, delivered Pittsburgh.

Bessemer pig iron has been scarce and the market has declined comparatively little. There has developed a remarkable shortage of ores of Bessemer grade, and this has affected the large steel interests as much as it has the merchant blast-furnace interests which buy their ore. Bessemer iron cannot be had at less than \$22, valley, the old price for any early delivery.

STEEL.

Several mills are actively soliciting billet orders, although in the Summer there were few sellers, and on some of the sales made several months ago, deliveries have been poor. These mills are well scattered geographically, and quote on Bessemer billets from \$27 to \$28 at their works, and \$28 to \$29 on open-hearth billets. There are no sellers in Pittsburgh or the immediate vicinity, and delivered Pittsburgh billets can be quoted at \$29 for Bessemer and \$30 to \$30.50 for open-hearth. There has been a decline of fully \$3 a ton in billets since July.

FINISHED MATERIAL.

Wire products were advanced a dollar a ton, effective Sept. 3, making wire nails \$2.05 per keg, base, in carload lots to jobbers, and plain wire \$1.90. The new prices are being shaded by some jobbers and some independent mills. It is probable that the advance was merely a strategic move, to protect contracts taken at the old figures.

Demand for merchant pipe has fallen off greatly, and good deliveries are obtainable at the base prices, whereas, two months ago contracts at these prices were taken subject to delay, guaranteed deliveries commanding a premium of \$2 to

\$4 a ton. On line pipe the mills are busy closing up deliveries for the season.

A fair amount of structural business is coming up and the fabricating shops and structural mills are in better shape than other lines, being pretty sure of relatively full operation for several months.

The large plate mills appear to have enough business to run them into next year, but the smaller mills are anxious for tonnage. Steel car business has been practically nil for months, and the car plants can hardly run much beyond the first of the year on old business.

Iron bars are still easier and can be had at \$1.65, delivered Pittsburgh. Otherwise we quote prices unchanged and well held as follows, f. o. b. Pittsburgh:

Structural shapes, \$1.70 per 100 pounds for beams and channels, 15 inches and under.

Plates, \$1.70 for tank quality.

Merchant steel bars, \$1.60, base.

Common iron bars, \$1.65, delivered Pittsburgh, and \$1.60, f. o. b. Pittsburgh for Western delivery.

Sheets, 28 gauge, \$2.60 for black, and \$3.75 for galvanized.

Tin plates, \$3.90 for 100-pound cokes.

The Danger of Overspecialization.

Dr. LEO BAEKELAND, equally distinguished as the inventor of velox paper for photographic purposes, and as the chemical engineer who reduced the Townsend electrolytic cell to practice on a large scale in the new alkali and chlorine works in Niagara Falls, recently addressed the New York Section of the American Chemical Society on the danger of overspecialization. From this address we herewith give some extracts. The full address may be found on pages 845 to 854, Vol. XV., No. 648 of "Science."

Dr. Baekeland emphasized that we ought to consider all pursuits of life from a broad general standpoint. Even now, our educational system is "still much under the chilling effect of that cloud, which, during the Middle Ages, hid the light of true knowledge." A tendency has manifested itself to reform this antiquated system of education, but this tendency now "seriously threatens us with the pitfalls of the other extreme."

"Furthermore, the fact that scientific learning has found unceasing applications in the production of wealth has fostered the constantly increasing tendency for finding a scientific education or scientific pursuits a mere means of earning a living or making money." * * * But "such men once having decided to enter a scientific profession, soon became aware that the call is for specialists, and they were forced to specialize one thing or another by their employers, whether the latter were manufacturers, merchants, or even some educational institutions whom they served as teachers."

"What is worse, our own way of living shows beyond doubt that we all have undergone, more or less, the effects of overspecialization against which I have come to protest."

"Busily burrowing along like moles, in the pursuit of our own little specialties, we are dizzily preoccupied with our specialized routine work. We lose the desire of coming once in a while upon the surface of the earth to take a stimulating look at the grand view of nature and its inspiring entity. Once, upon a while, we are rather disturbed in our narrow scientific beliefs when some Curie announces radium or radioactivity, or when some Ramsay upsets our orthodoxy by pronouncing the words: evolution of elements. We get fairly shocked when a Crookes speaks of death of matter."

"Just in the same way, after admitting as holy faith that weight and matter are constant or indestructible, some day, somebody may have to rouse the most timid of us and force us into the belief that gravitation, like all other energies, can be modified into any of them, or better perhaps, that gravitation, being the more stable of all energies, is the final energy

toward which light, heat and electricity tend to change. Who knows but that ultimately a less neglected study of gravitation may allow us a glimpse into the secret of the destiny of our universe?

"I admit, many of you will smile at these unorthodox hypotheses or conjectures. Yet, let me ask you: With what methods have we thus far measured any possible changes in weight? We have pinned all our faith, all our beliefs, on a mechanical instrument called a balance. A very delicate method indeed, if judged from our conceited one-sided standpoint of specialists. We are proud if we possess a balance which can weigh a one-hundredth of one milligram; we work ourselves into awe and admiration before an instrument such as the one I saw two years ago, which can detect difference of a one thousandth of a milligram. A one thousandth of a milligram! How infinitesimally small such a weight appears to our limited conceptions; and yet, what a ponderous quantity this same weight becomes if we try to compare it with the mass of an electron.

"Our whole science of chemistry is based on the fundamental law of the conservation of matter as formulated by Lavoisier and accepted by us as an axiom. However, by what means has this law been verified, if not by balances more crude, more imperfect, than the clumsy instrument which can not weigh anything beyond $1/1,000$ of a milligram? It is high time that science should discover a more delicate means for determining small weights than a mere mechanical balance; then, but only then, may we be able to demonstrate beyond doubt whether all the assumptions on which we base our chemistry are correct, or whether we simply have been building a whole science on false premises.

"While we are at this subject, let us continue this act of self-examination. When we speak of the descriptive part of the science of chemistry, when we describe any reactions, any compounds, any laws, we all refer these to phenomena which take place within an abnormally small range of temperature. Lately, Dewar opened our eyes to some unexpected phenomena which occur at very low temperatures; on the other hand, the electric furnace so ably manipulated by our regretted Moissan enabled him to establish many unsuspected facts at temperatures which our imperfect thermometric methods do not allow us to measure accurately. Yet, if we will drop for a moment our one-sided considerations and look upon everything in true proportions, we must admit that the range of temperatures within which we have studied natural phenomena is disappointingly small, as compared with the possible range of temperature of the universe.

"Not so long ago, chemists had no better definition for organic compounds than to designate them as those that were produced under the intervention of vital forces; inorganic bodies, on the contrary, were supposed to be made under the influence of ordinary physical forces. We all know since, how Liebig and Wöhler disposed of this mistake by the memorable discovery of the synthesis of ura from inorganic bodies. Nevertheless, many of us to-day are prone to think that the more delicate organic bodies, as, for instance, the constituents of the protoplasm, will never be obtained synthetically. These doubters point to the fact that as soon as we try to imitate these subtle, synthetic reactions which take place in the living cell we remain powerless to accomplish anything beyond splitting or simplifying the molecule. And yet, let me ask you, what are the laboratory methods with which we try to imitate the subtle biological processes? Heating, boiling, distilling, desiccation, precipitation, electric currents, every one of these barbarously destructive methods, with which we blast away at exceedingly delicate compounds: we might just as well try to imitate the melodious music of a Gounod by firing some dynamite cartridges between the delicate string of a piano.

"One sided as we are, we witness every day of our lives the fact that all vegetation accomplishes its processes of synthesis or assimilation under the indispensable action of light; never-

theless, thus far we have tried very little to avail ourselves of this powerful, yet delicate source of synthetic energy. Up till now photochemistry has scarcely been used for any other purposes but the art of photography.

"What have we done to utilize the effect of pressure in the study of natural phenomena?" * * * "And how about the element of time in chemical reaction?" * * *

CORRESPONDENCE

Utilization of Peat for the Generation of Power and the Production of Artificial Manure.

To the Editor of Electrochemical and Metallurgical Industry:

Sir:—With reference to your note on page 145 of your April issue on the utilization of peat, I am sending you copies of the reports prepared by Dr. Caro and me on the gasifying of peat with simultaneous production of ammonia.¹ Peat should not be looked upon solely as a new source of electrical energy, but other important general economical and agricultural considerations should be taken into account.

In agriculture in the United States the need of employing artificial fertilizers containing nitrogen is now manifest, and this need increases even more rapidly in the United States than in Europe. This is indicated by the figures of the imports of Chili saltpetre, which increased in the last five years from 185,000 to 374,000 tons. On the other hand, considerable quantities of ammonium salt were also imported in spite of the high protective tariff, since the home production did not meet the demand.

It is natural that farmers in the United States as well as in Europe do not like to depend in such a way on foreign producers. This is especially so in view of the fact that the producers of Chili saltpetre are in an exceedingly strong position as a result of their natural monopoly as well as of commercial trust formations. For this reason there should be a wide field in your country for utilizing new sources of nitrogen available in large quantities.

There are two such sources: the atmospheric air and peat, and the methods of utilizing these two sources supplement each other in a rational and interesting way. I have found, with Dr. Caro, that the gasification of 1 ton of peat yields 55 kg. of ammonium sulphate as by-product, while the main product, namely, 1,780 cubic meters of gas produced, yield 450 to 500 horsepower-hours. For the fixation of 1 kilogram of atmospheric nitrogen in form of calcium cyanamide 20-hp. hours are required. Hence the 450-hp. hours obtained from the gas would be sufficient for the fixation of 22.5 kg. of nitrogen, which are equivalent to the nitrogen content of 112.5 kg. of ammonium sulphate or 143 kg. of Chili saltpetre.

I should not omit that our analyses of samples of peat from the United States, and especially from Canada, show that there are in these countries large deposits of peat containing considerably more nitrogen than the peat which we have treated in this country. The content of nitrogen amounts in some American peat samples to 3 per cent, so that the output of ammonia will be correspondingly greater.

I will finally say that the very extended deposits of peat which exist in North America from Canada down to the Gulf of Mexico have hardly been utilized at all for industrial purposes, although they are to be found just at such places in the country where other natural sources of energy like water powers do not exist. They represent a wide and greatly promising field for the active work of electrical and electrochemical engineers in the United States for the best interests of agriculture and industry.

A. FRANK.

CHARLOTTENBURG, GERMANY.

¹ See page 406 of our present issue.—Editor.

VIENNA MEETING OF THE IRON AND STEEL INSTITUTE

The Autumn meeting of the Iron and Steel Institute (London) was held on Sept. 23 and 24 in Vienna, Austria. The program of the meeting included visits to the chief iron and steel plants of Austria-Hungary. Just twenty-five years had elapsed since the Iron and Steel Institute held their first Vienna meeting in 1882.

While the full report of the proceedings and discussions held at the meeting must be reserved for our next issue, we are enabled to give herewith abstracts of all papers presented at the meeting, from advance copies kindly forwarded to us by the secretary of the institute. The paper by Prof. Baron von Jüptner on the application of the laws of physical chemistry in the metallurgy of iron will be printed in full in one of our next issues.

The Austrian Iron Industry.

In a paper on the Austrian iron industry during the last twenty-five years, Mr. WILHELM KESTRANEK, general manager of the Prager Eisen-Industrie Gesellschaft and of the Böhmisches Montan Gesellschaft, could point with pride to the way in which Austria-Hungary has been able to hold its own in the list of iron-producing countries and to the important progress made in this period.

To characterize in general the position of the iron industry, it is interesting to note that during the last twenty-five years the world's production of pig iron increased in value from about 340 million dollars to about 960 millions, while the value of the production of gold rose from 102 million dollars to 390 millions. The value of the pig iron produced represents at the present time about two and a half times the value of the output of gold.

The annual production of pig iron in Austria-Hungary is now about 1,900,000 metric tons (against 600,000 in 1882). In sketching the natural influences which determine the growth of the iron industry in a country, Mr. Kestraneck made the following suggestive remarks.

"It can be taken as an axiom that the development of the iron industry of a country, in relation to the consumption, depends more on the richness of its fuel resources than on an abundance of iron ore. Thus it is seen that countries, such as Sweden and Spain, which are rich in ore and poor in fuel, export the greater part of their output of ores to countries rich in fuel, and are, in proportion to their wealth in ore, only small producers of pig iron. Other countries, on the other hand, such as Great Britain, which depends to a large measure on the importation of iron ores, and Germany—which also has to import considerable quantities of ore—occupy a leading position. It is unnecessary to mention the happy United States, which rejoices in the possession of an abundance of ore and of coking coal, and for this reason naturally occupies the leading position.

"The quantity and quality of the iron ores are as important a factor in commercial competition in the iron industry of a country as are the number and condition of the soldiers of an army; while the fuel resources are for the iron industry what the generalship and armament are for such an army. Under otherwise equal conditions the superiority in training and equipment of any army are more efficacious at the present time than mere weight of numbers. It therefore appears to me that the quality and quantity of fuel available are more decisive factors in the industrial development of the iron trade of a country than wealth of ores.

"If I may further develop this comparison, it may be mentioned that the conditions of two combatants are also naturally influenced by other important circumstances, such as the existence of ramparts, or in other words, protective duties;

further by the natural resources and financial wealth of the two competitors, which, in the case under consideration, is the demand of the home market. Finally, the fortune of war depends on whether the forces are kept free from disease. Such diseases, mostly of a contagious character, are strikes and the efforts of organizations to hinder production.

"As an example, I believe that the development of the British iron trade would have been far more successful if the introduction of technical improvements had not been hindered by the action of trade organizations."

The prosperity of the Austrian iron industry is principally impaired by the want of mineral fuel, and by the costly methods of transporting the fuel to the iron districts. Nevertheless the Austrian iron industry has been able to keep pace with other countries, chiefly for three reasons: sufficiently high protective import duties; the association of the iron works into a syndicate; and the concentration of the smaller works into larger units.

Theorists express the opinion that protective duties and trade syndicates hamper technical progress, because they put into the pockets of those interested abundant profits without any trouble. Opposed to this view, the Austrian iron industry can, with pride, point out convincingly that such a theory is devoid of foundation, because they are always endeavoring to improve their works technically. The Austrian iron-works have utilized all the modern methods for economical working, although they have been naturally limited, because their plant and appliances require to be fitted to a great variety of manufactures, and must be designed to suit the proportionately small consumption of the country. The Austrian iron industry has, therefore, to avoid mere slavish imitation of the gigantic works in the United States, and has modified modern methods to suit the given conditions."

The most extensive application of electricity is found everywhere in Austria, mostly in conjunction with the blast furnace gas engineer, and also coke-oven gas engines for the generation of power, and, as an example, in Witkowitz a plant of this description of 5,700 hp. exists.

At the Austrian blast furnaces which yield 790,000 cubic meters of gas per hour, 263,000 cubic meters are used for blast heating, so that 527,000 cubic meters are available. Of this quantity, at the present time 358,000 cubic meters, or 68 per cent are utilized for boiler heating, and 34,000 cubic meters, or 6.5 per cent representing 12,000 hp. in gas engines, whilst the remainder of the gas is used partly for ore-roasting or in drying kilns, and partly drawn off unutilized. The Böhmisches Montangesellschaft, which at present is utilizing blast-furnace waste gases on the most extensive scale, utilizes 23 per cent of the available gas in gas engines.

In the Austrian coke works, the coke ovens yield 86,000 cubic meters of gas per hour, of which quantity the coke ovens themselves absorb 62,000 cubic meters, so that 24,000 cubic meters are available. Of this quantity 5,700 cubic meters, or 24 per cent, are utilized in gas engines, whilst the remainder is used for boiler heating.

The most complete application of electricity to the driving of rolling-mills is in Teschen, where, not only the finishing, intermediate, and roughing trains, but also the reversing rolling-mills are driven by electric motors.

Finally it is very interesting to learn that the Austrian steel works engaged in the manufacture of high-grade alloy steels, especially tool steel, have lately adopted the new electric furnace processes. "Thus we find that the Poldihütte have adopted the Kjellin process, the firm Gebrüder Bohler & Co. are introducing the Keller electric process, and the new Styrian cast-steel works of Danner & Co. employ the Héroult

The first call on this power would, of course, be the satisfaction of the internal demands of the iron and steel works, the balance of power remaining being available for external distribution over a wide area. The pooling program would be provided by a separate and distinctive joint-stock electric power organization.

Instead of selling electric power to outside customers, the author considers the establishment of electrochemical and electrometallurgical industries, like the production of high-class steel from selected scrap, special alloys, such as ferro-silicon and ferro-titanium, ferro-chromium, besides the production of carbides (silicon and calcium). The production of calcium carbide is considered by the author to be an ideal associate for an ironworks, because the agents of production are coke, limestone and electrical energy.

Finally the following objection is dealt with; namely, supposing the market for iron does not justify the manufacture of pig, and it became financially imperative to blow out the furnaces, what about the supply to the pooling station under these circumstances. The author has solved this difficulty by designing a generator that, harnessed to the furnace-gas cleaning plant, produces gas of more or less exactly the composition of furnace gas.

The combustible portion of a typical example of this gas is chemically constituted as follows:

Per Cent.

Carbon monoxide	32.4
Marsh gas	0.4
Hydrogen	1.6

The cost of this apparatus is small, because the cleaning plant and associated gas mains are those installed for the furnace gas. Such a generator of the generating capacity of the pooled gas proportion from a given furnace would be available within three hours' notice, and the simplicity of the apparatus makes the question of depreciation during stand-by periods of little or no economic importance. The fluid slag from this generator can be readily converted into slag wool. This furnace type of gas generator, designed by the author, is being adopted by one of the most important of continental iron firms to compensate for the vagaries of furnace output. It was illustrated on page 262 of the *Journal of the Iron and Steel Institute*, 1906, No. III.

Ageing of Mild Steel.

Mr. C. E. STRÖMÉYER followed up his recent fifty-five page paper, which was abstracted on page 264 of our July issue, with another paper of twenty-three pages and numerous tables of microphotographs.

His researches have not yet revealed the test which will discriminate between reliable and treacherous qualities of steel. Bending tests of samples with sheared edges seem to be of no scientific value. Bending tests of samples with planed edges are even less useful. Bending tests of samples having planed and nicked edges seem to be the best tests yet devised for studying ageing qualities, but the injury done to the various plates by nicking, which is revealed by bending, does not appear to discriminate between plates which have high or low percentages of phosphorus, sulphur, etc., nor between those which have, and those which have not, behaved well in practice. The bending of nickel samples is therefore in this respect no better than the ordinary tensile, temper, and cold-bending tests.

The brittleness, revealed by the bending of nickel samples, more especially if the plates are maintained at a fairly high temperature, as in boilers, suggests that calking, particularly that injudicious calking which grooves the underlying plates, may initiate a local brittleness, which, after a time, might endanger the boiler if severely stressed. This may account for the explosions which were formerly so common amongst locomotive boilers having single-riveted lap joints, for at these joints the cylindrical form is replaced by a zigzag form, and instead of the simple tension stress there are locally very in-

tense bending stresses. These experiments would also suggest that the practice fairly prevalent on the Continent of Europe, of resorting to frequent hydraulic tests, which, of course, produce much higher stresses than those to which boilers are subjected to while working, may cause fractures.

The heating of structures which are severely stressed by other means than by nicking, may create a brittleness which may ultimately lead to fractures. At any rate the author's experience among marine engines is that crank-shafts are far more likely to crack if they have been carelessly allowed to get hot, than if they have been always kept cool while running. On the other hand, long exposure to cold has a less injurious effect on nicked samples than storing them at ordinary temperatures.

As a matter of fact, the author's tests go far towards dispelling the not uncommon belief that prolonged and intense cold may cause some steels to become brittle. The reverse is rather the case; for, according to the author's experiments, prolonged exposure to heat, and not to cold, tends to make mild steel brittle.

"For fear that these remarks may lead to a misunderstanding, it is desirable to mention here that there is nothing in these experiments to show whether mild steel is more or less brittle when cold than when hot, and that on this point one has to be guided by experience, according to which rails are known to snap more frequently in cold weather than in warm, and that boilers have practically never failed by cracking when in use. Explosions are due to other causes."

A New Iron Paint and a New Application of Calcium Chloride from the Pickling Process.

A paper by Mr. F. J. R. CARULLA refers to the utilization of the ferrous chloride, which is obtained from pickling iron and steel rods or plates in hydrochloric acid. The chloride waste pickle liquors are generally dealt with by adding some base, which, combining with the chloride, will precipitate the iron as an oxide, and that which naturally suggests itself is lime. But the calcium chloride produced thereby is also a very soluble and deliquescent substance, with little use for it, so that the process can only be resorted to as a necessity. Certainly the calcium chloride solution might be run away, but a better use might be to employ it for watering roads and preventing the dust arising from the passage of motor cars, a use to which this salt is said to have been successfully applied."

Dr. C. F. Wülfing has suggested to use ammonia to effect the precipitation. The value of the ammonium chloride, thereby obtained, is greater than that of the ammonia employed, but the main object is to obtain a black oxide of iron. This, however, is only produced after long exposure to air blast in the presence of ammonia and naturally the operation involves difficulties.

The volatile nature of ammonia requires special attention to be given to the apparatus which must necessarily be closed. In view of the necessity of an air blast some of the ammonia will be carried off by the air, and provision has to be made in the plant not to lose this ammonia.

The oxide which is obtained "has a beautiful blue-black color, is quite insoluble in water, and when passed into the filter-press leaves a clear solution of ammonium chloride, which is evaporated and allowed to crystallize. The blue-black iron oxide precipitate is magnetic, showing it to be Fe_2O_4 , and is a valuable addition to the list of pigments that can be employed with advantage for the production of structural iron work." With the use of other bases, instead of ammonia, it is not possible to obtain an oxide of equal quality.

Structures which have been painted with this blue-black oxide of iron (boiled linseed oil being used in the preparation of the paint) are said to have kept fresh, though exposed to the weather for nearly two years, still showing a varnish-like surface. The Sharon Chemical Co., Ltd., are putting up a plant in Derby to work this process.

Case Hardening.

The process of case hardening consists in adding such a percentage of carbon to a relatively thin outside layer of iron or mild steel, as will, on correct quenching, produce a hardened surface, while the inner core of the metal still retains its initial character. Mr. G. SHAW SCOTT, in a paper on this subject, remarked that "case hardening is fundamentally the same as the older process of cementation, the chief points of difference being that in case hardening, a different carbon-conveying material is used from that generally employed in cementation, whilst in the latter process the carbon is allowed to penetrate through, or nearly through, the bars, and is not interrupted so as to form merely a surface or "case" of carburized metal.

"Case hardening is somewhat allied to the Harveyizing and Krupp processes, both of which are employed for the hardening of armor plate.

"In the former process a solid carbonaceous cementing material is employed—usually charcoal; and in the latter a gaseous hydrocarbon is stated to replace the charcoal."

Mr. Scott's experiments were made with a variety of steel which is considered by the trade as specially suitable for case hardening, its composition being 99.16 per cent Fe, 0.14 C (combined), 0.01 Si, 0.08 S, 0.03 P, 0.58 Mn.

Of case-hardening mixtures were tried burnt leather (several varieties), wood charcoal, anthracite, sugar-charcoal, mixtures of barium carbonate and wood-charcoal, etc. Burnt leather was employed as the standard material, its composition being 77.80 per cent C, 3.20 N, 13.44 moisture, 5.56 ash.

Treatment of the test bars at 700° C. for 4 hours showed that absolutely no carbon penetration had taken place. A slight penetration—to the depth of 0.13 millimeter—was observed after similar treatment at 800° C., while at 900° C. the depth of carbon impregnation had increased to 1.58 millimeters.

Tests with different case-hardening materials and for different periods of time, but all carried out at 900° C., gave the following results:

	Burnt Leather "A."	Wood Charcoal.	Barium Carbonate and Wood Charcoal.
Time of Heating.			
2 hours.....	1.15 mm.	0.72 mm.	1.36 mm.
4 ".....	1.58 "	1.07 "	2.20 "
8 ".....	2.30 "	1.58 "	2.84 "
12 ".....	2.80 "	1.80 "	3.17 "
16 ".....	Right across specimen.		

The table shows that the most rapid penetration took place with the mixture of barium carbonate and wood-charcoal, while the least penetration resulted from the use of charcoal.

All the case-hardening materials in common commercial use contain nitrogen, and the beneficial effect of nitrogen is discussed in the concluding part of Mr. Scott's paper. The following experiment is instructive: Two exactly similar bars of standard steel were selected. One was heated in an atmosphere of ammonia for 4 hours at 550° C. The other meanwhile received no treatment. Afterwards, both were heated in separate cast iron boxes in a non-nitrogenous carbonaceous material (sugar-carbon) for 8 hours at 1,000° C. The bars which had received no ammonia treatment gave a penetration figure of 1.44 mm., those which had been treated with ammonia 1.80 mm.

A microphotographic study showed "twinning" (twins-crystal formation) to be a result of the ammonia treatment. Since Osmond has shown that twinning can only result when iron or steel is in the gamma condition, the author concludes that nitrogen is to be added to the list of elements which cause iron to take or retain the gamma form. And since gamma-iron combines more readily with carbon than does alpha iron, this action of nitrogen on the iron would appear to sufficiently explain its beneficial effect during the early stages of the process of case hardening.

A second paper on the case hardening of mild steel was presented by Messrs. C. O. BANNISTER and W. J. LAMBERT.

The mild-steel bars tested were 1 inch in diameter and had the following composition: 0.080 C, 0.535 Mn, 0.018 Si, 0.059 S and 0.088 P. They were embedded in ordinary "red scintilla" and heated as follows: Four samples at 871° C. for 2½, 5, 10, 20 hours, respectively, and two samples at 982° C. for 48 and 120 hours. The times given here are the actual periods at which the bars remained at the temperatures stated, independent of the time taken in heating them up.

The authors first studied the microstructure of the cemented bars. Of the various microphotographs reproduced in the paper, one is specially interesting, showing a crack developed on quenching. This crack occurred exactly between the supersaturated portion (on the outside) and the saturated portion (inside). These quenching cracks, which are often a great trouble in case-hardened goods, are evidently due to the unequal contraction of the portions containing different amounts of carbon on quenching.

The microstructure, showing the crack, belonged to the test bar, which had been heated for 120 hours at 982° C. The same bar was later subjected to analysis at different places. The outside portion, keeping well clear of the dark etching band, contained 1.37 per cent C, the middle of the dark etching band contained 0.90, towards the center, and well clear of the dark etching band, the percentage of carbon was 0.25, while in the center portion it was 0.13.

Very great care was taken to detect any trace of graphite carbon present, but the whole of the samples were soluble in dilute nitric acid, showing that graphite was not present. This is probably due to the fact that the temperature was kept below 1,000° C.

For the determination of the depth of carburization, the prepared surfaces of the soft specimens were measured to obtain the depth made evident by etching, and for the file-hardness test the hardened specimens were carefully ground down on a rotary grinding machine, the file being tried after the removal of each 1/100th of an inch from the side. In the following table, which gives the results, the first line gives the time of case hardening in hours, the second line the temperature in degrees C., the third line the depth, in inches, of cementation measured by etching in soft specimens, and the fourth line the depth, in inches, of file hardness in hard specimens:

Hours of hardening.	2½	5	10	20	48	120
Deg. C. of hardening.	871	871	871	871	982	982
Inches	0.020	0.030	0.039	0.052	0.108	0.236
Inches	0.015	0.020	0.023	0.027	0.090	0.095

The authors consider that the "solid-solution theory" is capable of offering a satisfactory explanation without bringing in the question of the formation of sub-carbides, etc. Thus in the four bars which were carburized at 871° C. the carbon penetrated the bars until they became saturated, that is, contained 0.9 per cent of carbon, and very little diffused as a more dilute solution than this, as shown by the very narrow ring of carburized metal within the saturated portion.

On the other hand, the bars carburized at 982° C. were supersaturated on the outside with the formation of free Fe₃C, and at this highest temperature the carbon was also capable of diffusing more easily as a dilute solution, as evidenced by the wider range of carburized metal within the saturated portion.

Hardened Steels and Metallography.

A suggestive paper on hardened steels by Mr. PERCY LONGMUIR, of Sheffield, begins with the following paragraphs:

"The ultimate test of a hardened steel is its working life as a tool, and whilst it may not be difficult to obtain the requisite hardness, it is difficult to obtain it with freedom from clinking or cracking, from brittleness or rottenness and from warping. The hardness test alone is therefore insufficient, and the non-recognition of this fact in the literature of hardening is to be

regretted. This is not, however, the only omission, and, generally speaking, the literature of hardening bears very little relation to the practice of hardening. As a result, practical men view with distrust researches on hardening, especially when founded on results deduced from microscopic examination. So much is this the case that the microscope is regarded by many competent workers as having hopelessly failed to be of service in the case of hardened steel.

"As a matter of fact, no metallographical investigation yet published has been of the least service as a guide to the thermal treatment of high-speed steels, and with few exceptions comparatively little information of value has been given on the hardening or tempering of carbon steels. These statements do not necessarily imply the condemnation of the microscope as a practical aid in the study of hardening, but rather emphasize the difficulties of interpretation, and also the fact that many scientific workers are unfamiliar with the practical aspects of work. This divergence between practice and theory has naturally led to controversy; but ignoring controversial questions as far as possible, an effort is made in the following paper to indicate briefly some variables in the case of carbon steels.

"The suitability of a quenched steel is a function of the carbon present, and so firmly is this recognized in practice that special care is always exercised to obtain the exact percentage which experience has indicated as being desirable. The usual range is from 0.5 to 1.5 per cent of carbon, but in special cases the latter figure is exceeded. The first essential, that of a suitable percentage of carbon, is most rigidly adhered to. Other features calling for note are as follows:

(1) The majority of articles for subsequent hardening are worked into shape from rod, string or strip, which in turn has undergone a considerable amount of work in reduction from the ingot. Only in exceptional cases are cast materials submitted to hardening.

(2) Whilst heating, temperatures may reach 1,000° C.; quenching temperatures never attain this point, and the usual practice is to quench at as low a heat as is consistent with the properties desired in the tool.

(3) Quenching baths, when of plain water, are usually aired, but never fall below atmospheric temperature.

(4) After water hardening, the majority of tools are tempered.

"In well organized works the processes of hardening and tempering are operated by specially trained workers, who achieve results of remarkable regularity. The practice of hardening is in a more advanced state than is realized by many scientific workers. As an example, a skilled hardener will harden and temper 7 gross of high-quality pocket knife blades per day of 9 hours. The tang of the blade is not hardened, but the full length of the blade must be hard. On spite of the rapidity of work, wasters due to faulty hardening are practically nil. Further, blades of like kind hardened by one man are, on microscopical examination, found to give regular structures which do not vary in different sections of one blade, nor yet do they appreciably vary from blade to blade. Similar conditions hold in the general cutlery and tool trades. Hardening operations are remarkably effective and, notwithstanding large outputs, very free from waste.

"Several works personally known to the author, engaged on most intricate hardening of a non-repeat character, have losses falling well below 1 per cent. In view of the variety of work handled, of every possible contour, and ranging in weight from less than an ounce up to 300 pounds the results obtained bear good testimony to the skill of the hardening personnel.

"However, notwithstanding the success achieved in hardening practice, there is still room for improvement, and when occasionally erratic results occur the natural object is to endeavor to ascertain the cause with a view to avoiding it in the future. Under these conditions practice, of necessity, has to rely on its own empirical experience."

In discussing the microstructure of commercially hardened steels the author arrives at the following important results: "The characteristic feature of a correctly-hardened steel is an absence of definite or pronounced structure, whereas, the leading trait of a spoiled steel is the presence of a definitely sharp structure."

The ideal condition represented by a lack of structure is obtained only in a certain range of quenching temperature, which varies according to the composition of the steel and the contour of the piece to be hardened. Temperatures outside this range result in more or less crystalline patterns, which in the smallest of sections vary from field to field. Although certain of these patterns may give the appearance of special constituents they are in reality the product of an abnormal quenching temperature, and steels containing them, although hard, are useless for cutting or resisting abrasion.

"The diversity of structure in normal and abnormal products quenched under unsuitable conditions explains to some extent the attitude of practical men towards the microscope, but instead of leading to condemnation it should rather lead to recognition of the value of microscopical examination. Diversity indicates wasters, whilst uniformity denotes correct hardening conditions. Working on these lines the author has found the microscopical examination of hardened steels of great assistance in the solution of problems met with in hardening practice."

The paper is concluded by the following remarks:

"The discrepancies in the literature of hardening are due to the fact that certain essential practical features have not met with recognition. Thus any hardened steel, previous to hardening, must have had a considerable amount of mechanical work put on it. Any mechanical stresses present must be relieved by annealing. If the properties of a hardened tool depended solely on the production of a certain type of structure, then cast tools would answer. Experience shows that the fullest properties are only reached on material which has been worked and annealed. Recognition of these features and a study of advanced hardening practice would result in the removal of many discrepancies and tend to elevate metallography into a science from which practical men could draw inspiration in times of difficulty."

A second paper on the hardening of steel had Mr. L. DEMOZAY, of Paris, as author. Since the results obtained in practice during the hardening of steel depend on the conditions under which the transformations of the metal take place, and particularly on the duration and the temperature of the heating, the energy of the quenching bath and the size of the pieces quenched, the author endeavored to analyze the part played by each of these different factors. The tests were made with samples of special nickel-chromium steel, and the results are given in numerous diagrams and tables.

With respect to the general conclusions the results are of a qualitative nature only. As to the heating operation, it is pointed out that the transformation point of a steel varies within two temperatures. The maximum value would be the temperature of transformation at the center of a very small sample rapidly heated to a high temperature. The minimum value would be the temperature of transformation at the surface of a large sample very slowly heated to a comparatively low temperature.

As to cooling, the point of transformation on cooling varies in a steel between two extreme temperatures. The maximum value would be that of the transformation of a point on the surface of a large sample slowly cooled. The minimum value would be that of the transformation at the center of a small sample rapidly cooled.

The effects of changing the size of the sample, of changing the temperature, and of considering different points within the samples—other things being equal—are also given in general statements.

Steel and Meteoric Iron.

Prof. FRED. BERWERTH's paper, which had been prepared with special reference to the celebrated and truly incomparable meteorite collection in the Imperial Natural History Museum in Vienna, was exceedingly suggestive by showing in a general way that meteoric iron and steel-works steels are results of essentially similar chemical and physical causes. Meteoric irons may, in their essentials, be properly included in the category of steel. The fundamental difference is that while artificially-produced steels are mainly iron-carbon alloys, meteoric iron-steel is an iron-nickel alloy with meteoric carbon.

The Erzberg of Eisenerz.

The Erzberg (ore mountain) of Eisenerz (iron ore) was the subject of a paper by Prof. H. BAUERMAN who discussed the geology of this important mineral deposit of the Eastern Alps and sketched the mining and metallurgical undertakings connected with this deposit.

Producer Gas-Fired Muffle Furnaces.

BY OSKAR NAGEL, PH. D.

In coal-fired muffle furnaces the combustion products escape at very high temperature after heating the muffle, which means a considerable loss of heat. Producer gas firing is much more economical in such a furnace, as the waste heat can be used advantageously for preheating the combustion air. Further-

space (*f*) surrounding the muffle. At the entrance the gas is mixed with hot air, which is led to these points through channels (*l*) between the gas channels from the recuperator. The gas flame rises upwards, plays around the muffle arch and goes downward, heating the bottom of the muffle. Then the products of combustion—still very hot—go through pipes (*r*) to the flues (*ee*) leading to the stack. The pipes (*r*) are built into the wider channels (*m*), into which air is led through channels (*p*). This air plays around the pipes (*r*) opposite to the flame direction, and is heated by absorbing through the pipe walls the heat of the combustion products. The highly preheated air finally goes through channels (*n*) into pipes (*l*), which lead to the fire space and are arranged between the gas pipes.

For effecting a uniform heating of the muffle, the producer gas can be led into the fire space also at a second and third place, and the sensible heat of the brick walls utilized for preheating the air necessary for oxidizing this quantity of gas. In the construction shown in the illustration, at half the way of the fire gases around the muffle, producer gas and preheated air is again allowed to enter. The air necessary for burning this gas enters at *t* and *t* through openings regulable by slides into the air slits *v v*, arranged behind the fire-brick wall of the furnace. The producer gas entering at the second place is also taken from the producers *g*.

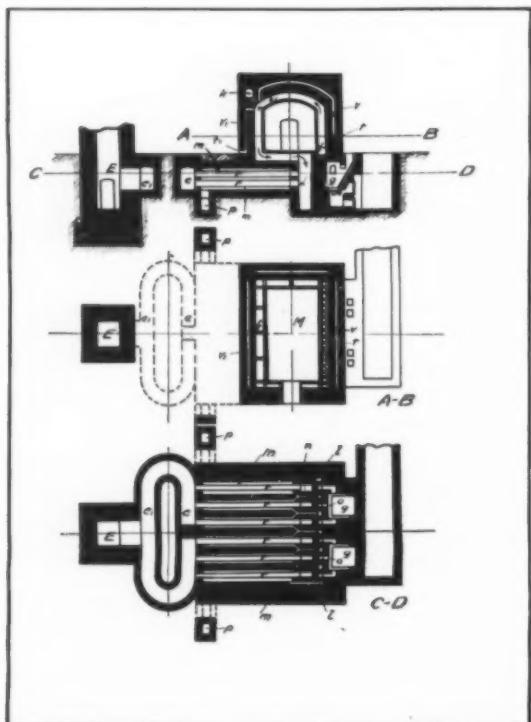
Metallurgical Calculations.

BY J. W. RICHARDS, PH. D.,
Professor of Metallurgy in Lehigh University.

The Electrometallurgy of Copper.

The electric current is used in metallurgy either for its electrolytic effects or for its electrochemical action. In the former the property of the current utilized is its ability, when passing in one direction through an electrolyte, of causing at the cathode a *reducing* action, such as the separation of metal from the electrolyte or the reducing of a ferric salt to a ferrous salt, and at the anode a *peroxidizing* effect, the direct opposite chemically of reducing, such as the taking of a metal into the electrolyte or the peroxidizing of a ferrous or cuprous salt to the ferric or cupric condition. In such a process heat is inevitably generated to some extent by the passage of the current through the ohmic resistance offered by the electrolyte. The extent to which heat is thus generated, coincident with the electrolytic action of the current, is of no significance whatever upon the nature of the process, which remains essentially *electrolytic* as long as the current is used for and performs its electrolytic decomposing function. However, when the heat thus coincidentally and inevitably generated in the operation of a process essentially electrolytic, is sufficient to keep melted an electrolyte which is not liquid at ordinary temperatures, the apparatus as a whole may not improperly be regarded as a furnace, and is very properly classed as an *electrolytic furnace*.

Electrochemical processes are those characterized by the absence of electrolysis, as shown by the arrangement and working of the apparatus, use of alternating current, etc., and in which the current is used solely for its heating effect. Such processes are carried on in *electric furnaces*, and are essentially processes in which chemical reactions or physical changes are brought about in the charge solely by the action of the temperature maintained by the assistance of the electric current. Metallurgically, the furnaces used are resistance furnaces, arc furnaces and combinations of the two. In resistance furnaces the heat operating the furnace is produced by the resistance either of the substance or charge itself, or by the resistance of a solid, liquid or granular resistor, intermingled with, in contact with, or placed in the neighborhood of the material to be



FIGS. 1, 2, 3.—PRODUCER GAS-FIRED MUFFLE FURNACE.

more, the sensible heat of the brick walls can also be utilized for preheating air by providing suitable air slots.

Figs. 1, 2 and 3 show a producer gas-fired muffle furnace. Fig. 1 shows a vertical section, Fig. 2 a horizontal section through the muffle proper, Fig. 3 a horizontal section through the recuperating apparatus.

The furnace shown in the illustration is provided with two producers *g*. The gas goes through openings (*O*) into the fire

heated. In arc furnaces the current jumps a gap between two poles, and generates locally the very high temperature of the arc, which is utilized by feeding the material to be treated into it or by bringing in close proximity to it. In the combined arc-resistance furnace, the material being treated forms one or both poles of the arc, and is therefore heated by the arc itself as well as by the passage of the current through its own substance.

In electrolytic processes the output of material, or commercial efficiency of the process, is essentially dependent upon the amperage of the current, since electrolytic effects are proportional to the amperes passing through the electrolyte. In electrochemical processes the commercial efficiency of output will vary with the total energy dropped by the current in the furnace, *i. e.*, will be proportional to the watts of current used up, not to its amperage or voltage, but to the product of these. Direct currents only are employed in electrolytic processes; direct or alternating may be used in electrothermal processes, but alternating are preferred, because of the complete absence of one-sided electrolytic effects when they are used.

Assuming familiarity with the ordinary non-electric metallurgy of copper, we may divide the electrometallurgy of copper into the following classes:

I. Electrolytic processes—

1. Direct treatment of ores.
2. Treatment of matte.
3. Extraction from solutions.
4. Refining of impure copper.

II. Electrothermal processes—

1. Direct smelting of ores.
2. Melting and casting of copper.

I.

Electrolytic Processes.

Copper has an atomic weight of 63.6. It occurs chemically as cuprous compounds, formula CuAl^I , or cupric compounds, formula CuAl^{II} , where Al^I is a univalent or monad acid radicle and Al^{II} a bivalent or dyad acid radicle. As a monad atom, copper has a chemical equivalent of 63.6, as a dyad element 31.8. The amounts of copper dissolved into or deposited from a cupric or cuprous salt are proportional to the chemical equivalent of copper in these two states and to the amperes flowing. Assuming that 1 amp. liberates electrolytically 0.00001036 grams of hydrogen per second, we will have as the amount of copper concerned in the passage of 1 amp. through one tank:

Cuprous Compounds.	Cupric Compounds.
1 Ampere, per second... 0.0006389 grams.	0.0003295 grams.
per minute... 0.03953 "	0.01977 "
per hour.... 2.372 "	1.186 "
per day.... 56.93 "	28.46 "
per year.... 20.78 kilograms.	10.39 kilograms.

A useful datum to remember, if one is used to working in English measures, is that 1 amp. deposits practically 1 ounce avoirdupois (28.35 grams) of copper per day in each cell, using cupric compounds, and 2 ounces for cuprous compounds, or, respectively, one-sixteenth and one-eighth of a pound per day. These figures are, of course, the theoretical figures for an ampere efficiency of 100 per cent.

I. 1—TREATMENT OF ORES BY ELECTROLYSIS.

There are no native ores of copper susceptible of being melted and electrolyzed—in the manner, for instance, that sodium nitrate (Chili saltpeter) can be melted and electrolyzed for the production of sodium. The most abundant ore of copper, its sulphide, occurs mostly mixed with several times its weight of foreign material, and even if picked out pure and melted it redissolves copper at the cathode so actively that no

electrolysis is possible. Faraday showed that melted cupric oxide is decomposed by the current; and if the oxides of copper were found anywhere in sufficient purity and quantity they could be melted and decomposed electrolytically, but hardly in any case as cheaply as they could be reduced by carbonaceous material.

Cupric chloride is found in nature as atacamite, with the formula CuCl^I . $3\text{Cu}^2\text{O}$, $2\text{H}_2\text{O}$, in a comparatively pure condition, but in small quantity, in Chili. Such material will dissolve in considerable quantity in melted salt (NaCl), and can then be electrolyzed. The dissolved copper salt is first reduced by the current, with evolution of chlorine, to CuCl , and then this decomposed. The quantity of this material is at present insignificant, but there is a possibility of an electrolytic process along this line.

Cuprous chloride does not occur in nature, but can be readily made from other copper-bearing material. Chlorine gas, for instance, converts the common copper sulphide, Cu^2S , into CuCl (Ashcroft's process). When melted, cuprous chloride conducts the current very well, copper separating out as fine leaves. The melt cannot be heated to the melting point of copper and the copper obtained liquid, because it vaporizes too easily. It is a good conductor, its resistivity at 50° above its melting point being only 6 ohms (per centimeter cube).

Problem III.

In electrolyzing a bath of melted cuprous chloride, using an unattackable anode, the electrodes are 5 centimeters apart, and a current density of 2 amperes per square centimeter is used.

Required:

- (1) The voltage required for running the bath.
- (2) The proportion of the energy of the current converted into heat.
- (3) The volume of chlorine, at 0° , liberated per minute by a current of 1,000 amperes.
- (4) The output of copper in kilograms per kilowatt-hour of electric energy employed.

Solution:

(1) The voltage required includes that necessary to overcome the ohmic resistance of the electrolyte plus that absorbed in chemical decomposition. With a resistivity of 6 ohms, current density 2 amps. per square centimeter, and distance between electrodes 5 c. m., the first item is

$$V^e = 6 \times 5 \times 2 \div 5 = 12$$

The second item comes from the heat of formation, by dividing that heat expressed per chemical equivalent by 23,040. Since $(\text{Cu}, \text{Cl}) = 35,400$ Calories, we have

$$V^d = 35,400 \div 23,040 = 1.5$$

The total voltage required would be

$$V^e + V^d = 13.5 \text{ volts.} \quad (1)$$

This is independent of drop of voltage at contacts of electrodes with the conductors. That may amount to 0.5 or 1.0 volt, unless the contacts are very closely looked after.

(2) The current drops as sensible heat:

$$12 \div 13.5 = 0.89 = 89 \text{ per cent of its energy.} \quad (2)$$

(3) Assuming 100 per cent efficiency of liberation of chlorine, we have:

Hydrogen gas liberated by 1 ampere, in 1 sec = 0.00001035 grams.

Chlorine gas liberated by 1 ampere, in 1 sec.

$$0.00001035 \times 35.5 \text{ (Chem. eq. wt.)} = 0.0003674 \text{ "}$$

Chlorine gas per 1000 amperes in 1 minute = 22.04 ".

Volume of chlorine, at 0° C.

$$22.04 \div (0.09 \times 35.5) = 6.9 \text{ litres.} \quad (3)$$

(4) One kilowatt, at 13.5 volts, gives $1000 \div 13.5 = 74$ amperes. This current, in one hour, will furnish, at 100 per cent efficiency

$$2.372 \times 74 = 175 \text{ grams of copper.} \quad (4)$$

Lower current densities would absorb less voltage and give a greater power-factor output.

I. 2—ELECTROLYTIC TREATMENT OF MATTE.

Matte is a mixture of Cu_2S with Fe_2S , and frequently impure with Pb , Zn , Ag , Au , As , Sb , Ba , etc. It melts sharply at about $1,000^\circ \text{C}$, to a thin liquid; it sets quickly to a hard, stony mass. When melted it can dissolve copper rapidly, so that electrolysis results in the matte being re-formed as quickly as it tends to be decomposed, and it apparently conducts the current without decomposition. If it could be dissolved in certain other fused sulphides in small amount, such as in fused sodium sulphide, it could conceivably be electrolyzed continuously, but no process has as yet been developed along these lines. If it could be dissolved in aqueous solutions of alkaline or other sulphides, it might be electrolyzed in such solvents, but no successful solvent of this nature has been found. It is not impossible that some aqueous solutions may be found to answer this purpose.

Solid matte is conducting, and may be used as an anode or a cathode. When so used it is acted upon by the electric current, reducing as cathode and perducingly as anode; that is, used as cathode it tends to be reduced *in situ* to metallic copper and iron, if there is any base present capable of uniting with and carrying away the sulphur; used as anode its copper tends to pass into combination with the acid radicle of the electrolyte, leaving the sulphur behind.

Use of Matte as Cathode.

Pedro G. Salom describes the use of this principle, called by him cathodic reduction, and has applied it on a large scale to the reduction of PbS concentrates, used as cathode in dilute sulphuric acid, to spongy lead. If the process is applied to granulated copper matte, assumed as nearly pure Cu_2S to simplify this discussion, the anode product is O_2 gas, and the cathode product H_2 gas mixed with varying quantities of H_2S . A. T. Weightman (Trans. Am. Electrochemical Society, II, [1902], 76) gives details of such an experiment.

Problem 118.

Fifteen grams of Cu_2S was used as cathode in a 5 per cent solution of H_2SO_4 , using an unattackable antimonial-lead anode. A current of 3.6 amps. was sent through for 3 hours (voltage not given). Area of electrodes 50 sq. c. m. each, distance apart 4 c. m. Gases contained H_2 and H_2S in the following proportions:

	H_2	H_2S
At 5'	42.4	57.6
At 180'	90.8	9.2
Average 0-180'	79.5	20.5

Required:

(1) The voltage required to run the cell, if H_2S alone were liberated, 100 per cent pure.

(2) The voltage required to run the cell at the beginning, at the end, and the average throughout the run.

(3) The proportion of the Cu_2S reduced to Cu during the run.

Solution:

(1) The voltage to overcome ohmic resistance requires first the resistivity of the electrolyte, which for 5 per cent solution is 4.8 ohms. The ohmic resistance of the cell is, therefore,

$$4.8 \times 4 + 50 = 0.38 \text{ ohm}$$

and the voltage drop to send 3.6 amperes through this

$$0.38 \times 3.6 = 1.37 \text{ volts.}$$

If H_2S were liberated pure, in which case the solution would be saturated with H_2S , the chemical reactions are



and the energy involved

(Cu_2, S)	= 20,300 absorbed
(H_2, O)	= 69,000 "
(H_2, S)	= 4,800 evolved

$$\text{Sum} = 84,500 \text{ absorbed.}$$

The voltage absorbed in producing this chemical reaction is:

$$\frac{84,500 + 2}{23,040} = 1.83 \text{ volts}$$

The total voltage necessary to run the cell is
 $1.37 + 1.83 = 3.20 \text{ volts.}$

(1)

(2) If no H_2S were formed, and the current liberated only H_2 gas, there would be absorbed in decomposition 1.50 volts, and by the cell as a whole 2.87 volts. Since a molecule of H_2S contains the same amount of hydrogen as a molecule of H_2 , equal volumes of H_2S or H_2 would be liberated by an equal electric current. It follows, therefore, that at 5 minutes 57.6 per cent of the current was performing reduction, liberating H_2S and 42.4 per cent liberating hydrogen.

The principle here involved in calculating the voltage dropped corresponding to the chemical work done is that of the composition and resolution of voltages, explained by the writer in Transactions American Electrochemical Society V. (1904), p. 89. The numerical result desired may be reached in several ways, for instance,

$$1.83 \times 0.576 = 1.054$$

$$1.50 \times 0.424 = 0.636$$

$$\frac{V^d = 1.69}{V^e = 1.37} \text{ volts}$$

but, for conduction,

therefore, total voltage, $V = 3.06$ "

At the end of the run we have similarly

$$1.83 \times 0.092 = 0.168 \text{ volts}$$

$$1.50 \times 0.908 = 1.362$$

$$\frac{V^d = 1.53}{V^e = 1.37} \text{ "}$$

$$V = 2.90 \text{ "}$$

For the average running

$$1.83 \times 20.5 = 0.375 \text{ volts}$$

$$1.50 \times 79.5 = 1.193$$

$$\frac{V^d = 1.57}{V^e = 1.37} \text{ "}$$

$$V = 2.94 \text{ "}$$

(2)

(3) Since 20.5 per cent of the current reduced copper during the run, the weight of copper reduced must have been

$$1.186 \times 3.6 \times 0.205 = 0.88 \text{ grams.}$$

But, the 15 grams Cu_2S contained, if pure,

$$\frac{127.2}{159.2} = 12 \text{ grams.}$$

Proportion reduced in the three hours

$$\frac{0.88}{12} = 0.073$$

$$= 7.3 \text{ per cent.}$$

(3)

This method of reduction of matte would need radical improvement before there could be any possibility of its commercial application.

Use of Matte as Anode.

This has appeared to many persons a hopeful application of electrometallurgy to copper. The matte is cast around some strips of copper, or copper netting is better, these giving the piece strength, preventing its disintegrating too quickly, and serving as conductors. Used in acidulated copper sulphate solution, the tendency is to dissolve out copper as copper sulphate and leave the sulphur as a residue. The latter is a non-conductor, forming an insulating layer, which increases greatly the voltage required to run the bath. Attempts to scrape off this layer are fruitless, because of the irregular,

cavernous corrosion of the anodes. Marchesi, an Italian, installed a plant to work this process near Genoa in 1882; a plant was also erected in Stolberg, Germany. Both were quickly abandoned as impracticable.

The theoretical reaction is for purest matte



so that for four chemical equivalents of copper deposited one molecule of Cu_2S is broken up. The voltage corresponding to the chemical work done is, therefore,

$$\frac{20,300 \div 4}{23,040} = 0.22 \text{ volt.}$$

The voltage required by the cell is this plus that absorbed in overcoming the ohmic resistances of the circuit.

If the matte were only FeS , the reaction would consist in the solution of iron, sliming of sulphur and deposition of an equivalent amount of copper:



and the energies involved are

$$\begin{array}{ll} (\text{Fe, S}) & = 24,000 \text{ Calories absorbed} \\ (\text{Cu, S, O}^4, \text{aq.}) & = 197,500 \quad " \quad " \\ (\text{Fe, S, O}^4, \text{aq.}) & = 234,900 \quad " \quad \text{evolved} \end{array}$$

$$\text{Sum} = 13,400 \quad " \quad "$$

and the voltage contributed to the circuit is

$$\frac{13,400 \div 2}{23,040} = 0.29 \text{ volt.}$$

If the matte is, as it usually is, part Cu_2S and part FeS , then when it is uniformly corroded there occurs a combination of the above two reactions. If the matte corresponded, for instance, to the formula $\text{Cu}_2\text{S} \cdot \text{FeS}$, and these were simultaneously acted upon, the current would be divided in the proportions required by the preceding reactions; that is, twice as much to handle the Cu_2S as for the FeS . The voltages concerned will enter into the calculation in the proportions 2 to 1, and the calculated voltage of decomposition will be

$$\begin{array}{ll} 0.22 \times \frac{2}{3} & = 0.147 \text{ volt} \\ 0.29 \times \frac{1}{3} & = - 0.097 \quad " \\ \hline \text{Sum} & = 0.15 \quad " \end{array}$$

The calculation can be made for any proportions of Cu_2S and FeS , remembering that every 159.2 parts of Cu_2S requires twice as much current as 88 parts of FeS .

Problem 112.

Marchesi erected and operated for some time an electrolytic plant using copper matte as anodes. The matte used contained 30 per cent copper, 30 sulphur and 40 iron, and the anodes measured 800 x 800 x 30 m. m., and weighed 125 kilograms. The cathodes were 700 x 700 x 0.3 m. m. The tanks were lead lined, with interior dimensions 2,000 x 900 m. m. x 1,000 m. m. deep. Electrolyte an acid solution of copper and iron sulphates. Resistivity assumed at 6 ohms. The plant contained 120 tanks, arranged in ten groups of twelve each, each group being run by a separate dynamo. Current density, 30 amperes per square meter of cathode surface; each tank contained twenty anodes and twenty-one cathodes. Conductors, 30 m. m. diameter; total length to one group 10 meters.

Required:

- (1) The electrical current required by each group of twelve tanks and the motive power to run its dynamo.
- (2) The rate at which the anodes lost weight per day.
- (3) The rate at which FeSO_4 accumulates in the bath, in per cent of the weight of the bath.
- (4) The output of copper per day.
- (5) The length of time necessary to plate 1 c. m. of copper on one side of each cathode plate.

Solution:

(1) The first point to be solved is the voltage required per tank, and that consists of voltage absorbed by ohmic resistance and that of chemical decomposition. The first must be found from the ohmic resistance of the baths, the second from the chemical reactions involved.

With twenty anodes, each 30 m. m. thick, and twenty-one cathodes (the end ones against the ends of the tank) 0.3 m. m. thick, the thickness of electrodes in a tank is

$$\begin{array}{l} (20 \times 30) + (21 \times 0.3) = 606.3 \text{ mm.} \\ \quad \quad \quad = 60.6 \text{ cm.} \end{array}$$

and the free space between, in the length of the tank, is

$$200.0 - 60.6 = 139.4 \text{ cm.}$$

Since this is divided into 40 spaces, the free space is

$$139.4 \div 40 = 3.5 \text{ cm.}$$

The total anode surface is, assuming them entirely immersed,

$$80.0 \times 80.0 \times 2 \times 20 = 256,000 \text{ sq. cm.}$$

and of the cathodes,

$$70.0 \times 70.0 \times 2 \times 20 = 196,000 \text{ sq. cm.}$$

giving current passing through a tank

$$19.6 \times 30 = 588 \text{ amperes.}$$

Since the tank is wider and deeper than the plates, the effective cross-sectional area of electrolyte is 25.6 sq. m. at the anode surface, 19.6 sq. m. at the cathode surface, and greater than either (by spreading of current lines) in between. It will not be far wrong, under these conditions, to take the effective area of the electrolyte as about that of the larger electrode, viz.: at 25.6 sq. m. The resistance of the tank thus becomes

$$R = \frac{6 \times 3.5}{256,000} = 0.000082 \text{ ohm.}$$

and the voltage absorbed in overcoming ohmic resistance

$$0.000082 \times 588 = 0.048 \text{ volt.}$$

During active corrosion, if copper and iron are dissolved in the proportions 30 to 40, this would be, in chemical equivalent proportions as

$$30 \div 31.8 \text{ to } 40 \div 28$$

or as

$$0.943 \text{ to } 1.429$$

since the current divides, in doing mixed electrolysis, in proportion to the number of chemical equivalents dissolved or deposited. It thus results that $0.943 \div (0.943 + 1.429) = 0.4 = 40$ per cent of the current is dissolving copper and 60 per cent dissolving iron. The corresponding voltage of the chemical work is, therefore,

$$\begin{array}{ll} 0.22 \times 0.40 & = 0.088 \\ 0.29 \times 0.60 & = - 0.174 \\ \hline \text{Sum} & = - 0.086 \text{ volt.} \end{array}$$

The sum of these two voltages is

$$\begin{array}{ll} V^e & = 0.048 \text{ volt} \\ V^d & = - 0.086 \quad " \end{array}$$

$$V = - 0.038 \quad "$$

The conclusion is, that as long as the surface of the matte is clean, and no resistance offered by the non-conducting sulphur slime, that the bath will really require no outside current to run it, but will practically run itself. The resistance of connections would absorb the small excess of voltage produced. This is as far as calculation can go. Practical experience with the bath records that the voltage required quickly rose to 1 volt, and after a few days running reached 5 volts. It is practically certain that this was caused entirely by the non-conducting film formed on the anodes.

(2) With 588 amps. passing and 40 per cent dissolving copper, or 235 amps., the copper dissolved per day in one tank is

$$\begin{array}{l} 28.46 \times 235 = 6.688 \text{ grams} \\ \quad \quad \quad = 6.688 \text{ kilograms} \end{array}$$

and the weight of matte dissolved per day

$$6.688 \div 0.30 = 22.3 \text{ kilograms}$$

Since the 20 anodes in a tank weigh $20 \times 125 = 2500$ kilograms, their loss of weight per day is

$$22.3 \div 2500 = 0.009 = 0.9 \text{ per cent} \quad (2)$$

and to lose their whole weight would theoretically require

$$100 \div 0.9 = 111 \text{ days.}$$

Practically, the plates went to pieces in about half that time, when about one-half of their weight had been dissolved.

(3) The iron dissolved is 40 per cent of the matte decomposed, or 8.9 kilograms per day. This forms

$$8.9 \times \frac{152}{50} = 24.2 \text{ kg. FeSO}_4.$$

The tank is not quite full of solution, but say to within 3 cm. of the top. This gives a space of

$$200 \times 90 \times 97 = 1,746,000 \text{ c.c.} \\ = 1.746 \text{ cm.}$$

From this would be deducted the volume of the electrodes:

$$80 \times 80 \times 3 \times 20 = 384,000 \text{ c.c.} \\ 70 \times 70 \times 0.3 \times 21 = 34,300 \text{ "} \\ \hline \text{Sum} = 418,300 \text{ "} \\ = 0.418 \text{ cm.}$$

$$\text{Volume of solution} = 1.328 \text{ "}$$

Assuming its specific gravity as 1.2, the weight of solution in a tank is

$$1.328 \times 1.2 = 1594 \text{ kilograms}$$

and its content of FeSO_4 is increased per day

$$24.2 \div 1594 = 0.015 = 1.5 \text{ per cent.} \quad (3)$$

The total salts present in the electrolyte, however, do not increase quite that fast, for since 16.73 kg. of copper are deposited per day and only 6.67 kg. are dissolved, the electrolyte loses copper at the rate of 10.06 kg. per day, equal to 25.24 kg. of CuSO_4 per day, which is 1.6 per cent of the weight of the electrolyte. We may, therefore, say that the electrolyte would lose 1.6 per cent of its weight of CuSO_4 per day and gain 1.5 per cent of FeSO_4 —amounting to a virtual displacement of CuSO_4 by FeSO_4 until the copper was all removed. This would result in not many days running before the electrolyte would have to be replaced.

(4) We have previously calculated, for one tank, that 16.73 kg. of copper is deposited per day. This amounts for the whole plant to

$$16.73 \times 120 = 2008 \text{ kilograms} \quad (4)$$

Of this amount, however, only $6.67 \times 120 = 800$ kg. came from the matte, and the rest from the solution. Ample means must therefore be provided to supply fresh CuSO_4 solution, which was obtained by Marchesi from the roasting and leaching of ore.

(5) Precipitated copper has a density of 8.9. One amp. precipitates per day 28.46 grams. One amp. per square centimeter would therefore deposit in a day

$$\frac{28.46}{8.9} = 3.2 \text{ cubic cm.} \\ = 3.2 \text{ cm. thickness.}$$

But the current density used for depositing by Marchesi was only 30 amperes per square meter, = 0.003 amperes per square centimeter, which would deposit a layer per day of

$$3.2 \times 0.003 = 0.0096 \text{ cm.} \\ = 0.096 \text{ mm.}$$

To deposit a layer 1 cm. thick would therefore require

$$1.0 \div 0.0096 = 104 + \text{days.} \quad (5)$$

This is a much slower rate of deposition than is used at present in copper refining, where 100 to 500 amperes per square meter (9 to 45 amps. per square foot) are used. Low-current

density deposits purer copper and absorbs less power, but gives a smaller output for a given installation, with consequent higher interest charges, labor costs, amortisation and general expenses.

I. 3—ELECTROLYTIC EXTRACTION FROM SOLUTIONS.

This branch of the subject covers some promising processes, which have not, however, been as yet practically successful. Their consideration, however, from a quantitative point of view, is not devoid of interest or lacking in instruction.

The waters of many copper mines carry copper sulphate, produced from the weathering and leaching of copper sulphide ores. The solutions are generally too dilute to allow of concentration and crystallizing out to blue vitriol. The standard method of treatment is to pass the solutions over pig iron or scrap iron, thus precipitating the copper as a sort of metallic mud, called "cement copper," which contains much iron, besides the impurities of the iron used, so that it is sometimes only 90 per cent down to 60 per cent copper. This precipitate needs a strong refining to bring it up to merchant copper, with considerable loss of copper in the operation.

Two electrolytic methods are applicable to the treatment of such solutions: 1. The use of soluble iron anodes. 2. The use of insoluble anodes.

1. Use of Soluble Iron Anodes.

If iron in plates or sheets or bundles of scrap iron in a crate or holder is immersed in copper sulphate solution and simultaneously connected electrically with a copper plate to serve as cathode, no copper precipitates on the iron, but all is precipitated on the copper. The iron acts as a soluble anode, going into solution as ferrous sulphate, while the copper is deposited out massive, dense, and practically chemically pure, on the cathode sheet. Since more energy is developed by the solution of the iron than is absorbed in the deposition of the copper, there is electromotive force generated by the chemical action, which will run the tank like a short-circuited battery cell, if the iron and copper are simply connected by a low-resistance wire. This electromotive force will send a current of a certain amount through the cell, depending on its internal ohmic resistance plus the resistance of the external conductor. If it is desired to force matters, and to precipitate the copper faster than this auto-precipitation, an impressed electromotive force from a dynamo may be put on, and the cell made to work faster.

Problem 113.

A copper sulphate solution whose resistivity is 50 ohms is run for precipitation through tanks, each of which contains fifteen anodes of cast iron 40×80 c. m in size, and sixteen sheets of copper of similar size, the distance between averaging 5 c. m. The anodes and cathodes are short-circuited by resting on a triangular copper distributing bar of negligible resistance. Assume resistance of contacts to be such that 0.1 volt will be lost at them.

Required:

(1) The electromotive force generated by the chemical action.

(2) The total current operative in each tank, and the current density.

(3) The weight of copper deposited in each tank per day.

(4) The weight of iron dissolved in each tank per day.

Solution:

(1) From the thermochemical tables (Metallurgical Calculations, Part I. p. 24) we have:

$$\begin{aligned} (\text{Fe, S, O}^4, \text{aq.}) &= 234,900 \text{ Calories} \\ (\text{Cu, S, O}^4, \text{aq.}) &= 197,500 \text{ "} \end{aligned}$$

$$\text{Excess of anode energy} = 37,400 \text{ "}$$

Since this is generated for each atom of copper deposited

and of iron dissolved, the excess energy per chemical equivalent concerned is $37,400 \div 2 = 18,700$ Calories, and the total electromotive force developed is

$$18,700 \div 23,040 = 0.81 \text{ volt.} \quad (1)$$

(2) The loss of voltage at the contacts being 0.1 volt, there is 0.71 volt operative to overcome the ohmic resistance of the solution. From the data given, the fifteen anodes operating on both sides, sandwiched between sixteen cathodes, give

$$15 \times 2 \times 40 \times 80 = 96,000 \text{ sq. cm.}$$

active electrode surface, and taking this as the cross-section of the electrolyte between, we have its resistance as

$$50 + 96,000 \times 5 = 0.0026 \text{ ohm}$$

the total current passing in the tank

$$0.71 \div 0.0026 = 273 \text{ amperes} \quad (2)$$

and the current density

$$273 \div 9.6 = 28.4 \text{ amperes per square meter}$$

$$= 2.6 \text{ amperes per square foot} \quad (2)$$

(3) Copper deposited in the tank per day:

$$28.46 \times 273 = 7770 \text{ grams}$$

$$= 7.77 \text{ kilograms}$$

$$= 17.13 \text{ pounds.} \quad (3)$$

(4) The iron going into solution will be to the copper dissolved as 56:63.6. If the iron is cast iron, this may be only 90 to 93 per cent of the loss of weight of the anodes, because they contain only that percentage of iron. If wrought iron or steel sheets were used, the iron dissolved would represent 99 to 99.8 per cent of the loss of weight of the anodes. The iron dissolved per day is

$$7.77 \times 56 \div 63.6 = 6.84 \text{ kilograms}$$

$$= 15.08 \text{ pounds.} \quad (4)$$

Problem 114.

One hundred tanks of the kind described in Problem 113 are arranged in a series, the anodes in each tank, however, connected as one large anode, and the cathodes in each as one large cathode. A dynamo is connected to the series capable of maintaining 110 volts across its terminals. The bus-bars provided are altogether 280 meters long, and are 1 x 4 c. m. in cross-section, of pure copper. All other details of the tanks are as before: resistance of contacts being 0.1 volt $\div 273$ amps. $= 0.0004$ ohm.

Required:

- (1) The ohmic resistance of the bus-bars.
- (2) The current operative in the circuit, and the current density.
- (3) The weight of copper deposited in each tank per day.

Solution:

(1) The conductivity of copper, in reciprocal ohms, is 600,000; its resistivity $1 \div 600,000 = 0.00000167$ ohms. This is its resistance per centimeter cube. The resistance of the bus-bars is therefore

$$0.00000167 \times 28000 \div 4 = 0.0117 \text{ ohm.} \quad (1)$$

(2) The total voltage operative in the circuit is the self-generated voltage of 100 tanks, plus the 110 volts from the dynamo, or

$$(0.81 \times 100) + 110 = 191 \text{ volts.}$$

The total resistance of the circuit is that of the 100 tanks, plus 100 sets of connections, plus that of the bus-bars

$$(0.0026 \times 100) + (0.0004 \times 100) + 0.0117 = 0.3117 \text{ ohm.}$$

The total current flowing will therefore be

$$191 \div 0.3117 = 618 \text{ amperes} \quad (2)$$

and the current density

$$618 \div 9.6 = 64.4 \text{ amperes per square meter}$$

$$= 5.9 \text{ amperes per square foot} \quad (2)$$

$$(3) 28.46 \times 618 \div 1000 = 17.59 \text{ kilograms per day}$$

$$= 38.79 \text{ pounds per day} \quad (3)$$

2. USE OF INSOLUBLE ANODES.

If insoluble anodes are used, the copper may be extracted

en masse from such solutions, and its acid left behind. In such operations, the choice of an anode is not easy. Graphitized carbon plates are unattacked, and have practically no back electromotive force; high-silicon iron plates are also said to be very resistant, and pure silicon itself resists still better, but introduces considerable ohmic resistance. Sheet lead anodes become coated with a brown coating of PbO_2 , which is permanent and evolves oxygen freely. Many other substances may possibly be used as anodes; not many practical results of such tests have been published. When operating thus, the electrolyte offers practically the same ohmic resistance as before, averaging probably a little less, and the chemical reaction absorbs energy. The resulting acidified solution may be utilized for dissolving easily-attacked copper compounds from fresh quantities of raw or roasted ore.

Problem 115.

An electrolytic depositing plant treats dilute copper sulphate solution containing 318 grams of copper per cubic meter as CuSO_4 , and its copper is deposited by passing through tanks having insoluble anodes, electrodes 3 centimeters apart, and current density of 20 amps. per square meter. With good circulation, copper is precipitated with no evolution of hydrogen until the precipitation is practically complete. By having many tanks in series the current passing is kept very nearly constant at 300 amps. Each tank contains 1.5 c. m. of electrolyte.

Required:

- (1) The voltage absorbed in the chemical reaction when precipitating copper, and when the copper is all precipitated.
- (2) The voltage absorbed in overcoming the ohmic resistance of the electrolyte at starting and at the end of the precipitation.
- (3) The total voltage across the electrodes of a tank, at the beginning of the precipitation, just before the last of the copper is precipitated and after all copper is precipitated.
- (4) The time required to precipitate the copper from a batch of solution.
- (5) The output of copper per average kilowatt-hour of electric energy used, adding 0.2 volts to the potential across the electrodes for loss in contacts and bus-bars per tank.

Solution:

(1) When precipitating copper, we destroy $\text{CuSO}_4 \text{aq.}$ and form the corresponding $\text{H}_2\text{SO}_4 \text{aq.}$ Their heats of formation being

$$(\text{Cu, S, O}^4, \text{aq.}) = 197,500 \text{ Calories}$$

$$(\text{H}^2, \text{S, O}^4, \text{aq.}) = 210,200$$

and since the reaction is



we have to supply

$$(\text{Cu, S, O}^4, \text{aq.}) = 197,500 \text{ Calories}$$

$$\text{H}^2, \text{O} = 69,000 \text{ "}$$

$$\text{Total} = 268,500 \text{ "}$$

and get back $(\text{H}^2, \text{S, O}^4, \text{aq.}) = 210,200 \text{ "}$

therefore supplying net $= 58,300 \text{ "}$

and voltage absorbed in decomposition

$$58,300 \div 2$$

$$= 1.27 \text{ volts.} \quad (1)$$

$$23,040$$

When the copper is all deposited, then only H^2 and O appear at the electrodes, so that the voltage absorbed in decomposition becomes

$$\frac{69,000 \div 2}{23,040} = 1.50 \text{ volts.} \quad (1)$$

(2) At starting, the solution contains

$$318 \times \frac{159.6}{63.6} = 798 \text{ grams}$$

of CuSO_4 per cubic meter, and since the cubic meter weighs at 15° practically the same as water, *i. e.*, 999.1 kg., our solution is

$$\frac{798 \div 1000}{999.1} = 0.08 \text{ per cent } \text{CuSO}_4$$

$$\frac{159.6}{159.6} = 0.01 \text{ normal.}$$

and also equals $0.798 \div 2 = 0.01$ normal.

At the end of the electrolysis the 0.01 normal CuSO_4 solution becomes a 0.01 normal H_2SO_4 solution. The resistivities of both these solutions can be found at once from electrochemical tables (*e. g.*, Kohlrausch, in Landolt-Bornstein-Meyerhoffer's Tabellen).

$$\begin{aligned} 0.01 \text{ Normal } \text{CuSO}_4 &= 1 \div 0.0005717 = 1395 \text{ ohms} \\ 0.01 \text{ Normal } \text{H}_2\text{SO}_4 &= 1 \div 0.000308 = 325 \end{aligned}$$

With a current density of 20 amps. per square meter (0.002 per square centimeter) and a working distance of 3 c. m., the corresponding voltages absorbed in overcoming these ohmic resistances will be

$$\begin{aligned} 1395 \times 3 \times 0.002 &= 8.37 \text{ volts} \\ 325 \times 3 \times 0.002 &= 1.95 \text{ "} \end{aligned} \quad (2)$$

(3) The total voltage across the electrodes, assuming the solution to contain no free acid at starting, will be

at start, precipitating copper: $8.37 + 1.27 = 9.64$ volts

at close, precipitating last copper: $1.95 + 1.27 = 3.22$ "

at close, evolving hydrogen: $1.95 + 1.50 = 3.45$ "

(4) Copper present in a tank: $318 \times 1.5 = 477$ grams.

Time required, 300 amperes

$$\begin{aligned} 477 \div (300 \times 0.0003295) &= 4826 \text{ seconds} \\ &= 1 \text{ hr. } 20.5 \text{ min.} \end{aligned} \quad (4)$$

(4) The average voltage consumed in overcoming ohmic resistance will be considerably less than the mean of 8.37 and 1.95 = 5.16 volts, because when the electrolysis is only half completed, and the solution is 0.005 normal in each ingredient, its resistance will be 487 ohms, and not $(1.395 + 325) \div 2 = 800$ ohms, and the corresponding voltage 2.92. This is because sulphuric acid is a so much better conductor than CuSO_4 , that as soon as acid forms the solution becomes much better conducting. If we calculate the resistances and corresponding voltages absorbed in several steps, we would get more accurate results. Without going into the detailed calculation we will take 3.52 as the average voltage, and we then have the average voltage required per tank:

Decomposition	1.27	volts
Resistance	3.52	"
Contacts	0.20	"
	—	—
Sum	4.99	"

Kilowatts used per tank

$$\begin{aligned} 4.99 \times 300 \\ \hline 1000 \end{aligned} = 1.497 \text{ kw.}$$

Output per tank per hour

$$300 \times 1.186 = 355.8 \text{ grams.}$$

Output per kilowatt-hour

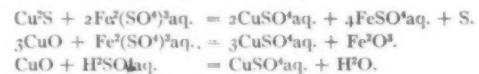
$$355.8 \div 1.497 = 238 \text{ grams.} \quad (4)$$

This is, of course, a small output compared with that of a refining process, but it must be remembered that this is an *extraction* process, and its cost is not properly comparable with simple refining but with that of the processes which it replaces, such as precipitation by iron, and with cheap power and expensive iron there may be localities where this method would be economical.

Siemens and Halske invented a combined wet-extraction and electrolytic process, consisting in leaching the roasted copper ore or matte with a solution of ferric sulphate acidu-

lated with sulphuric acid, producing thus a solution of cupric and ferrous sulphates, and then electrolyzing this solution in a cell having an insoluble carbon anode and a diaphragm between the electrodes. The solution is run first through the series of cathode compartments, where its copper is extracted, and back through the anode compartments, where its ferrous sulphate is reduced to ferric sulphate, ready to be used again in leaching ore.

The chemical reactions in leaching ore are



In the electrical precipitation we have:

$$\begin{aligned} \text{in the cathode compartments: } \text{CuSO}_4 &= \text{Cu} + \text{SO}_4 \\ \text{in the anode compartments: } 2\text{FeSO}_4 + \text{SO}_4 &= \text{Fe}^2(\text{SO}_4)^2 \\ \text{altogether: } 2\text{FeSO}_4 + \text{CuSO}_4 &= \text{Cu} + \text{Fe}^2(\text{SO}_4)^2 \end{aligned}$$

Confining our calculations to the electrolysis, we have CuSO_4 destroyed and 2FeCO_4 simultaneously reduced to $\text{Fe}^2(\text{SO}_4)^2$, which is then available for re-use in the leaching tanks. The chemical work involved is:

$(\text{Cu}, \text{S}, \text{O}_4, \text{aq.})$	$= 197,500$	Calories absorbed
$2(\text{Fe}, \text{S}, \text{O}_4, \text{aq.})$	$= 460,800$	" "
$(\text{Fe}^2, \text{S}^2, \text{O}_4^2, \text{aq.})$	$= 650,500$	" evolved
Sum	$16,800$	" absorbed
$16,800 \div 2$		
Voltage thus absorbed	$\frac{16,800}{23,040}$	$= 0.36$ volt.

In addition to this, the voltage necessary to overcome the ohmic resistance of the cell must be counted in.

Problem 116.

An electrolytic tank for working the Siemens-Halske method was of wood, lead lined, 220 c. m. long, 100 c. m. wide and 100 c. m. deep. Each cell contained fifteen anodes and sixteen cathodes, the latter 80 x 80 c. m. x 1 m. m. The anodes were of carbon rods arranged as a grid 45 c. m. x 100 c. m. x 1 c. m. thick. A porous partition 1 c. m. thick was used, the equivalent effective free area of which was 0.05. Resistivity of electrolyte in cathode compartment 5 ohms, in anode compartment 8 ohms, partition in middle. Current density 100 amperes per square meter.

Required:

(1) The distance between the diaphragm and each anode and cathode surface, and the resistance of the cell, taking into consideration the contraction of current path due to the diaphragm.

(2) The voltage necessary to run the tank.

Solution:

$$\begin{aligned} (1) \quad 15 \text{ anodes} \times 1 &= 15 \text{ cm.} \\ 16 \text{ cathodes} \times 0.1 &= 1.6 \text{ "} \\ \hline \text{Sum} &= 16.6 \text{ "} \end{aligned}$$

Space, anode to cathode

$$\frac{220 - 16.6}{30} = 6.8 \text{ cm.}$$

Space, anode or cathode, to diaphragm

$$\frac{6.8 - 1}{2} = 2.9 \text{ cm.} \quad (1)$$

Assume the solution in the diaphragm to have mean resistivity of 6.5 ohms, the equivalent free area being $100 \times 95 \times 0.05 = 475$ sq. c. m. (area of diaphragm a trifle less than cross-section of tank). Mean area of electrolyte:

$$\begin{aligned} \text{cathode compartment} & (6400 + 9500) \div 2 = 7950 \text{ sq. cm.} \\ \text{anode compartment} & (4500 + 9500) \div 2 = 7000 \text{ " "} \end{aligned}$$

Resistance of			
anode compartment	$8 \times 2.9 \div 7000$	= 0.0033 ohm	
cathode compartment	$5 \times 2.9 \div 7950$	= 0.0018 "	
diaphragm	$6.5 \times 1 \div 475$	= 0.0137 "	
		<hr/>	
	0.0188	"	(1)

Voltage absorbed, for 64 amperes (to 0.64 sq. m. depositing surface)			
	0.0188×64	= 1.20 volts	
	V_d	= 0.36 "	
	<hr/>		
	V	= 1.56 "	(2)

Carl Hoepfner devised a process along similar lines to the above, but based on the use of the two chlorides of copper. A solution of CuCl^2 in brine is used to act upon the ores or roasted matte, dissolving the copper with the formation of CuCl .



The cuprous chloride stays in solution in the brine, and is electrolyzed in tanks containing diaphragms, half the solution going through the cathode compartments and half through the anode compartments. In the former, copper is precipitated; in the latter, the equivalent amount of chlorine converts the CuCl present into CuCl^2 , which can be used over, mixed with the depleted cathode solution. The total reaction is



and the energy involved

$$\begin{aligned} 2(\text{Cu}, \text{Cl}) &= 70,800 \text{ absorbed} \\ (\text{Cu}, \text{Cl}^2) &= 62,500 \text{ evolved} \\ \hline \text{Sum} &= 8,300 \text{ absorbed} \\ &= 0.18 \text{ volt.} \end{aligned}$$

Cochn devised a cell for carrying on this process without a diaphragm. The cathode is only half as long as the carbon anode, and the CuCl^2 formed at the latter is so heavy that it sinks to the bottom and is drawn off therefrom, while fresh CuCl solution is quietly poured in above. Since the cathode does not touch the cupric solution, it is not redissolved thereby, and the two solutions are kept separate.

A great advantage of this process is that Cu is monovalent in CuCl , and therefore twice as much copper is deposited as from CuSO_4 by a given number of amperes.

Problem 117.

Cochn (Jahrbuch der Electrochemie, 1895, p. 155) describes his improved partitionless Hoepfner apparatus as containing a copper cathode 100 c. m. wide by 50 c. m. deep, at a distance of 12 c. m. from a carbon anode; solution, 10 per cent NaCl , plus varying amounts of CuCl and CuCl^2 . Current density 20 amps. per square meter.

Required:

- (1) The voltage required to run the cell.
- (2) The weight of copper deposited therein per day.
- (3) The weight of copper per kilowatt-hour electric power used.

Solution:

- (1) The resistivity of 10 per cent NaCl solution is 8.5 ohms.

$$R = \frac{8.5 \times 12}{5000} = 0.051 \text{ ohm}$$

$$V_c, \text{ for ohmic resistance} = 0.05 \times 10 = 0.51 \text{ volt}$$

$$V_d, \text{ for chemical reactions} = 0.18 "$$

$$V = \text{Sum} = 0.69 "$$

$$(1) \quad 28.46 \times 2 \times 10 = 569 \text{ grams per day} \quad (2)$$

$$(3) \quad 569 \div 24 + (10 \times 0.69) \div 1000 = 3435 \text{ grams.} \quad (3)$$

[The rest of the electrometallurgy of copper will be treated in our November issue.]

The Utilization of Peat for Power Purposes with the Recuperation of Byproducts.

The utilization of peat is one of those subjects in which a host of investors have interested themselves and much money, ingenuity and energy has been spent to lead this intricate problem towards a solution. One of the most active workers in this field for a long series of years has been Prof. A. FRANK, of Charlottenburg-Berlin, the same German chemical engineer who distinguished himself many years ago by his active work in introducing potassium salts into agriculture and quite recently by inventing, together with Dr. Caro, the process of making calcium cyanamide from calcium carbide. Anything that this successful engineer has to say on the difficult problem of peat utilization should, therefore, find most careful attention, especially as the matter will most likely become of great importance in future in this country.

This article is based on five papers, kindly sent to us by Dr. Frank (see also his letter in our correspondence columns in this issue). It is very interesting to see how the methods of utilizing peat have been gradually worked out, until now finally the commercial stage appears to have been reached. The titles of the five papers are as follows:

Über Verwerthung der norddeutschen Moore, insbesondere für elektrische Kraftstationen. Lecture held by A. FRANK on Oct. 4, 1897. (Berlin: L. Simion, 1897.)

Über Torfgasbetriebe für grosse elektrische Centralen. Report presented by A. FRANK on Dec. 17, 1903, to the Central-Moor Commission.

Die Bedeutung des Torfes für die Provinz Ostpreussen. Two lectures held on Nov. 16, 1906, by N. CARO on the peat bogs as sources of energy, and by W. FELDT on the peat bogs as sources of raw materials and the utilization of peat deposits for agriculture. (Danzig: Verband Ostdeutscher Industrieller, 1907.)

Über Gewinnung und Verwendung von Torf zu Heizzwecken und zur direkten Krafterzeugung. Lecture held by A. FRANK on Feb. 13, 1907. (Berlin: Deutsche Tageszeitung, Druckerei und Verlag A. G., 1907.)

In the Northern climate peat deposits are formed wherever stagnant water can accumulate. Peat is an accumulation of decayed vegetable matter, its decomposition still going on. The decay of the vegetable matter (mosses, roots, etc.) is an effect of the water, and first takes place in presence of air, while in later periods air has no longer access to the forming peat. That the formation of peat is still going on is shown in places by observing an actual growth of the peat deposits in the course of years.

FUEL MADE FROM PEAT.

The direct applications of peat for agricultural purposes, the methods of working peat areas so as to make them available for farming, the use of peat as litter are discussed in the paper of Dr. Feldt quoted above, and need not be referred to at this place.

To understand the possibility of using peat for industrial purposes it is necessary to consider its composition. This varies greatly with respect to the content of water, the content of ash, the content of nitrogen, etc., but the "peat substance" proper, that is, the pure organic substance of the peat, has a rather uniform composition, namely, 60 per cent carbon, 5 per cent hydrogen, 35 per cent oxygen.

The water and the ash in the peat are simply obnoxious. The content of nitrogen may be made use of for the production of useful nitrogen compounds. On the other hand, the composition of the peat substance proper given above shows that it represents a storage of energy, since carbon as well as hydrogen when oxidized set free considerable quantities of heat. Peat deposits, therefore, represent enormous quantities of stored-up energy.

The difficulties in recovering the energy stored in peat are

due to the composition of the peat and to its structure. Peat always contains large quantities of water. Although the water may be reduced by previous trenching of the area, yet the content of water in peat should be always assumed as 80 to 90 per cent, and it becomes necessary to further reduce it artificially. The use of mechanical pressure to remove the water has not been found satisfactory. On account of the porous spongy structure of the peat, there are formed quickly under pressure impervious layers on the outside of the pressed volume, so that further removal of water is prevented. The same difficulty is found when the water is removed by sucking off or by the recently proposed method of electric endosmosis (see ELECTROCHEMICAL AND METALLURGICAL INDUSTRY, Vol. I., p. 252). In any case so much power is required that the method is not economical.

The best method is always to first dry the peat in air, as was done already 2,000 years ago as recorded by Pliny. It has been proposed to combine this method of drying in air with a subsequent artificial drying by heat, the product being called "darrtorf," or to dry peat to a water content of 50 or 60 per cent and then compress it, the product being called "trockenpressorf." Dr. Caro, however, thinks that neither of these methods is necessary, since it is possible to get quite satisfactory results by natural drying in air alone.

If the natural peat is directly dried in air the process takes a long time and the product is porous, hygroscopic and brittle, containing about 20 to 25 per cent water and having a low specific gravity; *i. e.*, there is little fuel per unit of volume.

Better results are obtained by the use of peat milling or crushing machinery. If in such machines the fibers are torn apart and the peat is kneaded, compressed and mixed, a uniform product is obtained which dries more quickly than natural peat and has a much denser structure, so that a solid cohesive product of comparatively high specific weight and a content of 15 to 20 per cent of water is obtained. (See also our Vol. III., p. 421.)

"Machine peat" prepared in this way represents quite a satisfactory fuel which may be used for all purposes of heating. One kilogram of such peat may evaporate 3.5 to 4.2 kg. of water. Wherever the use of such peat as fuel has failed a wrong construction of the furnace has been at fault. The dimensions must be quite large on account of the comparatively low heat value of peat, and air must be supplied in proper amounts in order to secure complete combustion and permit the escape of the water which is in the peat and which forms during the burning process, as will be seen below.

Nevertheless, peat is an inferior fuel, and the use of peat as fuel must always be restricted to certain localities where other fuels are expensive. There is no possibility of peat competing with coal, though the latter sells at a fair price.

Dry Distillation of Peat and Production of Peat Coke.

Since peat represents chemically an intermediate stage between wood and bituminous coal it was to be expected that dry distillation of peat would yield a satisfactory coke together with tar, ammoniacal liquor and acetic acid as by-products. When peat is subjected to dry distillation—that is, under absence of air—water is formed from oxygen and hydrogen in the peat itself. Further oxygen and carbon in the peat combine to carbon monoxide and carbon dioxide, and finally hydrocarbons are formed from carbon and hydrogen in the peat. These products are distilled off and the balance of the carbon which remains back forms the coke. The first experiments were made, as in the distillation of wood, with "meilers," but these were not satisfactory. Better results are obtained with coking the machine-peat in closed retorts heated from the outside. The coke thus produced is rather hard, and the gas has such a calorific value that all the heat necessary for the distillation is provided by the gas. Further acetic acid and ammoniacal liquor are obtained.

A system which treats peat in this way is that of Ziegler,

which has proven satisfactory and profitable in a plant in Oldenburg, while a similar plant in Rjedkino in Russia has been unsuccessful. The success of such undertakings depends on many factors, and greatly on local conditions. The price of peat coke depends on its purity, that is, on the quantity of impurities in the raw peat. In his lecture, 1907, Dr. Frank exhibited some samples of Ziegler peat coke from the new Upper Bavarian Coke Works in Beuerberg, and stated that this coke was of very satisfactory quality and would be a good substitute for charcoal. Nevertheless, the Ziegler process requires a rather pure peat, very low in ash, as raw material, and the necessity of preparatory treatment in machines is a disadvantage.

Peat Gas Producers and Generation of Power.

The processes which we have considered so far relate to the application of peat as fuel, either in the form of peat fuel or peat-coke fuel. In any case, it is important to first dry and compress the peat for these purposes down to somewhat like 20 per cent of water. Further, if one wants to produce good peat coke, one is restricted to the use of peat low in ash as raw material. Such processes may be profitable at certain places under local conditions, but they do not represent the solution of the general peat problem.

Prof. Frank attempts this solution in another way. Instead of trying to subject peat to a treatment that would make it available for shipment to industrial centers, he says we must endeavor to bring industry and commerce into the peat-deposit districts. Peat areas should be considered just like waterfalls, as centers of stored-up energy. In his first paper (1897) Frank considered the erection of large generating stations in the peat districts with reciprocating engines, the peat being used as fuel under boilers. But even in those early days Frank considered that it might be possible to gasify the peat in gas producers and use the gas directly in gas engines. This idea was taken up more strongly in his second paper (1903), since the large gas engine operated by producer gas, blast-furnace gases and coke-oven gases had made its appearance in the meantime in the industry. In this paper he estimates that in a gas-engine plant it is possible to produce about twice the amount of power which can be produced from the same amount of peat in a steam-engine plant.

In this paper (1903) it is also mentioned that the generation of a suitable producer gas from lignite and peat has been proven practical, that lignite gas engines are operating at the Mansfeld Gewerkschaft, near Eisleben, and on the Sophien mine, near Meuselwitz, and that peat gas engines have been built by the Deutz Gas Engine Co., by Koerting Bros., by Julius Pintsch, by the Oberursel Machine Co., and others. The Deutz Gas Engine Co. reported that when using air-dried peat, containing 16.57 per cent water, 1-hp. hour requires 1.27 kilogram of peat, while according to a later statement the same company has succeeded in reducing the quantity of peat required for 1-hp. hour to 0.85 or 0.9 kg.

But what is still more important, it is by no means necessary in such processes to dry the peat to such an extent that it contains only somewhat like 20 per cent of water. It is quite possible to gasify peat containing 50 to 55 per cent of water. Moreover, in this process, it is possible to recover almost the total nitrogen contained in the peat in form of ammonia.

In the dry distillation of peat only a small amount of the nitrogen is changed in ammonia, as is proven by the fact that peat coke thus produced contains considerable amounts of nitrogen; as an example the following analysis of peat-coke is given by Caro: 86.41 per cent C, 1.57 H, 1.26 N, 7.09 O, 3.67 ash.

On the basis of the well-known Mond process, Dr. Caro has worked out a new method for gasifying peat in a mixture of air and overheated steam in excess. This process has been tried with Irish peat on the Mond works in Stockton, and it

has been found that almost the total amount of nitrogen in the peat is changed into ammonium sulphate, which can be easily sold as fertilizer.

At the Stockton works the output from 100-kilogram peat, calculated as free from water and containing somewhat more than 1 per cent nitrogen, was 2.8 kilograms ammonium sulphate and 250 cubic meters of producer gas with a calorific value of 1,300 calories.

Dr. Caro gives the following results obtained in tests in Winnington, England, where there is a large Mond gas producer plant. The Mond gas producers which were available there were partly used for gasifying peat. The peat gas was supplied to the gas engines which were otherwise operated with Mond gas, and ammonium sulphate was recovered in the same works.

The engineer in charge of the gas engine plant did not know whether he received Mond gas or peat gas, because all gas came through the same supply mains. He did not even find the difference in the operation of the gas engines.

Italian peat was employed in these tests since they were made in the interest of a projected works in Italy.

"Six hundred and fifty tons of peat were gasified in the whole. The composition of the peat substance, assumed free from water, was ash 15.2 per cent, volatile substances 43.8 per cent, nitrogen 1.62, total carbon 56.3, fixed carbon 34.2, with a calorific value of 5,620 large calories. The peat was used in different conditions, mostly with an average content of 40 per cent water, and 1,780 cubic meters of gas with a calorific value of 1,360 large calories were obtained per ton of water-free peat substance. Besides this there were obtained 118 British pounds = 55 kilograms ammonium sulphate per ton of water-free peat. I state again that this was not ammonia gas, but real salt which was weighed.

"The gas was partly used for generating the steam required for the gas producer process, partly for heating the ammonium sulphate solution, and besides this an excess of gas was obtained, namely, for each ton of water-free peat gas was obtained giving 480-hp. hours in gas engines.

"In this plant the cost of the treatment of 100 tons of peat (the weight being calculated on the basis of water-free peat) was \$50, including wages (\$1 to \$1.25 per man per day), repairs, etc. Further, for the production of the ammonium sulphate, sulphuric acid, costing \$41.25 (at \$7.50 per ton), was used. Finally, if the amortization is taken as \$33.75 (at 10 per cent), the total cost is \$125. On the other hand, from these 100 tons of water-free peat ammonium sulphate in the amount of about \$325 was obtained. This shows a good profit, especially if it is considered that the gas is supplied to the gas engines in absolutely pure condition.

"It has been found that the segregation of dust particles in a gas which has been freed from ammonia, takes place with much greater speed and intensity than in peat gas containing tar. One cubic meter of gas contained only 0.16 gram of tar, and the gas engines operated with this gas very well and without trouble. The content of hydrogen in the gas does not vary more than $\frac{1}{2}$ per cent in the maximum.

"The cost of the 480-hp. hours produced was, of course, very low. If we do not take into account the profit from the ammonium sulphate the cost of the electric horsepower-hour was less than 0.125 per cent."

Finally, peat gas produced in this way is not only suitable for generation of power, but may be used for all kinds of heating purposes if proper furnaces are employed. Its use in steel works recommends itself, since it is absolutely free from sulphur.

In order to test the process in the interest of German industry, an experimental plant is being erected on the Mont Cenis mine in Sodingen, in Westphalia, as was already mentioned in our April issue, page 145, for the treatment of waste coal and peat. If successful, the chief result will be the use of wet non-briquetted peat in gas producers for the generation

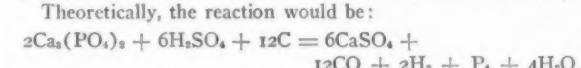
of cheap power and the production of ammonium sulphate. The income from the latter alone is expected to assure a fair interest on the capital; \$187,500 is given as the capital invested in this plant. The results of these tests will certainly be awaited with interest.

Production of Phosphorus in the Electric Furnace.

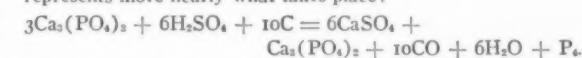
In a recent publication of the United States Geological Survey, entitled "The Production of Phosphate Rock and Phosphorus in 1906," Mr. GEORGE W. STOSE gives an interesting summary on the development of the manufacture of phosphorus and of the rôle which the electric furnace has played in this development.

Phosphorus was formerly produced from bones and other organic substances, and it is only recently that it has been extracted from mineral deposits. The mineral from which phosphorus was first obtained was rock phosphate, an impure fluophosphate of calcium, from which soluble phosphate fertilizer is generally made. Apatite, a fluophosphate, or chlorophosphate of calcium, has been used in Europe and Canada to a small extent. Quite recently wavellite (aluminium phosphate) has become a source of phosphorus, a sufficiently large supply of this deposit being available at Mt. Holly Springs, Pa.

The old method of making phosphorus that has been in use since the beginning of the nineteenth century is as follows: Bones are roasted and crushed, and the powdered bone ash (calcium phosphate) is treated with sufficient sulphuric acid to convert all or part of the calcium into calcium sulphate and the phosphorus into calcium metaphosphate, or even into phosphoric acid. This is partially evaporated, mixed with powdered charcoal, and reduced in a furnace in a clay retort. Phosphorus vapor and carbon monoxide distill off, and the phosphorus is condensed under water in a yellow waxy form. Theoretically, the reaction would be:



It is found in practice, however, that the following equation represents more nearly what takes place:



In this process much loss is occasioned by the destruction of the retorts by the acid and the intense heat, and only about one-half of the phosphorus in the charge is recovered. There is also danger of igniting the phosphorus when removing it, and great delicacy is required to prevent the vapor from condensing in the tubes and clogging them. Many improvements and modifications of this process have been patented in recent years. Woehler early suggested that calcium phosphate, either burnt bones or rock phosphate, be heated with sand and carbon without the sulphuric acid treatment, and the Wing patent, 1891, followed the same general method.

Wing Process.—In the Wing process the charge of bone ash, or pulverized rock phosphate, and silica is moistened and made into balls and is placed in layers in the cupola with coal between, which furnish incandescent carbon to reduce the phosphoric acid fumes. The silica releases the phosphoric acid from the phosphate in the form of anhydride P_2O_5 , which is reduced by the incandescent carbon and a reducing flame to phosphorus. The fumes pass off to depositing chambers kept at a temperature of 500° F., where most of the phosphorus is deposited in the red form and the remainder is caught in a water chamber as yellow phosphorus. The process is made continuous by feeding the charge from the top, dumping the residuum from the grate below, and using two depositing chambers alternately. With only the ordinary furnace at command this method was found impracticable on account of the high

degree of heat required to smelt so refractory a charge. Electricity as a powerful heating agent had been known for some time and was looked to as the solution of the problem, but the invention of the electric furnace has only recently made it commercially feasible. It has now been generally introduced throughout Europe and America in the production of phosphorus on a profitable basis.

Readman Patent.—This is the process which, since its introduction in 1889, has come into commercial use in most countries. Bone ash or crude phosphoric acid is mixed with powdered coal or charcoal or, if mineral calcium phosphate is used, it is roasted, crushed and mixed with charcoal and silica or some basic salt. The mixture is reduced in a continuously operated electric furnace in a reducing atmosphere, by passing the current from carbon electrodes through the mass, which acts as a resistant conductor and is heated to incandescence. The silica combines with the calcium to form calcium silicate slag. The phosphorus and carbon monoxide distill off as before. Distillation begins at 1,150° C., and requires 1,400° to 1,500° C. to complete the process. The chemical reaction is $2\text{Ca}_3(\text{PO}_4)_2 + 6\text{SiO}_2 + 10\text{C} = 6\text{CaSiO}_3 + 10\text{CO} + \text{P}_2$.

Harding Process.—In Harding's patent, 1898, pulverized rock phosphate is boiled with sulphuric acid, and the phosphoric acid, free from lime, is filtered out and boiled down to a sirup. This is mixed with granulated carbon, heated in a reverberatory furnace, and then smelted in an electric furnace by electric arcs between the electrodes and the mass. A hydrogen atmosphere is obtained by spraying gasoline into the furnace.

Gibbs Furnace.—In this furnace, which was devised especially for phosphorus manufacture, the electricity instead of discharging through the mass passes through a continuous high resistant medium, such as a carbon rod, placed above the charge. The rod becomes incandescent, and the roof, which is arched over the grate, reflects the heat as in a reverberatory furnace.

Irvine Furnace.—The Readman process was modified by the Irvine patent in 1901. The charge is the same as in the earlier method, although either aluminium or calcium phosphate can be used with the silica or basic salt flux. The two carbon electrodes are suspended vertically from above and are connected below at the start by coal, through which the current passes. After the charge melts the slag forms on top, and thereafter the current passes through it as the conductor between the electrodes. Fusion is continuous, and the excess of slag is tapped off gradually so as not to expose the ends of the electrodes.

Duncan Patent.—A process patented in 1903 by Duncan takes 77 parts of powdered phosphate, either organic or mineral, and 23 parts of powdered carbon, mixed with tar as a binder. This is dried, and after a preliminary heating as a matter of economy in a hydrogen flame, a by-product in the manufacture, it is placed in an electric furnace and calcium phosphide continuously produced. This is put into a chamber submerged in hydrogen; after adding water it forms phosphorus hydrides. Upon heating the hydrides are reduced to phosphorus in pure state, either red or yellow, depending upon the degree of heat at which it is allowed to deposit.

Parker Patent.—In 1902 Parker patented a process in England for the reduction of aluminium phosphate. It is treated with sulphuric acid and then with an alum-forming sulphate, all the alumina being removed by the crystallization of the alum previous to the electric treatment. The residual liquor is mixed with coal and other carbonaceous material and reduced in an electric furnace.

Landis Method.—The American Phosphorus Co., of Philadelphia, have a plant at Yorkhaven, Pa., where they extract phosphorus from wavellite by a method invented by Mr. G. C. Landis, chemist of the company. The process, which is kept

a secret, is, so far as could be learned, similar to the Readman method, except for the ore and the furnace. Wavellite, aluminium phosphate and calcium phosphate, obtained from South Carolina, are roasted, mixed with silica and charcoal, and reduced in the patent electric furnace. In January, 1907, a patent was secured on certain improvements in the furnace designed to prevent the escape of fumes, vapors and gases, or their absorption by the furnace lining. This is accomplished by an outer lining of non-absorbent brick and by a sealing device for all openings into the furnace whereby the projecting flanges of the joints are inclosed in a moat of water. The furnace has an inner lining of carbon bricks which acts as one electrode, and one or more vertical carbon electrodes are used which may be adjusted either to furnish a continuous current through the charge or to produce with it an electric arc. The slag is drawn off every 3 or 4 hours and the phosphorus fumes condensed under water. Probably some additional treatment is required to remove the alumina in the batch similar to the Parker patent, and this is what is kept secret. (For details of construction of the Landis furnace and a diagram of the same see page 55 of our February issue. See also page 378 of our September issue.)

The phosphorus obtained by most commercial processes is a crude form of white or yellowish waxy variety, and contains sand, carbon, clay and other impurities. These are removed in various ways—by filtering while molten through powdered charcoal or canvas submerged in water, by forcing the molten mass through porous pottery by means of steam, and by redistillation in iron retorts. The best method of purification, however, is to treat the crude phosphorus, when molten, with a mixture of potassium dichromate and sulphuric acid, or sodium hypobromite, some of the impurities being dissolved, others rising to the surface as scum.

Because ordinary white phosphorus is very poisonous and injurious to handle, other forms of the element have been sought. Red amorphous phosphorus, which is not poisonous, is readily prepared by heating the ordinary variety to 250° C. in a closed vessel under pressure or excluded from air and water. It has not the same qualities, however, as the white crystalline variety. A red crystalline form, recently discovered in Germany, is made by heating to boiling a 10 per cent solution of white phosphorus in phosphorus tribromide. This is not poisonous and is an efficient substitute for white phosphorus in making matches.

The industry in this country is so young that statistics are difficult to obtain; in fact, general information on the subject is lacking. The world's production of phosphorus has been variously estimated to be from 1,000 to 3,000 tons a year, and until very recently this was almost entirely a foreign industry. The greater part of the world's supply is made in the Albright & Wilson factory, Wednesfield (Oldbury), England, where the Readman process originated. The output is said to be 500 tons a year. Other large factories are located at Lyon, France, and at Griesheim and Frankfort, Germany. There is also a plant in Sweden, and numerous smaller ones in Russia, six of which, located near Perm, had an output of about 140 tons in 1890.

In the United States the first phosphorus works were built about forty years ago in Philadelphia by Mr. Moro Phillips, and this factory has continued in operation until very recently. The J. J. Allen's Son's plant was established in Philadelphia in 1891, and it supplied the Diamond Match Co., the largest match factory in the United States, in competition with imported phosphorus. In 1897 the English firm of Albright & Wilson, under the firm name of the Oldbury Electro-Chemical Co., built a 300-hp. factory of the Readman type at Niagara Falls, which thereafter supplied the Diamond Match Co. and the greater part of the domestic product. This firm has recently made a further improvement in its plant by introducing the Irvine patent furnace, by which method 80 or 90 per cent of the phosphorus is reported to be extracted from the raw

material, a high-grade phosphate rock. This is similar to the results obtained in the English works, where 86 per cent is recovered. They have six furnaces of 50 hp. each with a capacity of 170 pounds of phosphorus a day, a total of 1,000 pounds a day. Their production varies according to the demand, but they furnish at present over 50 per cent of the domestic product.

The General Chemical Co. recently acquired the Duncan patent. Another company was established at Long Island, where it operated furnaces by electricity from city supply.

The American Phosphorus Co. built its first plant in 1902, at Moores Mill, near Mt. Holly Springs, Pa., where its wavellite mine is located. The old method of heating by gas was employed. This mill burned down, and another was built and put in operation by 1905. Electric furnaces were installed in the new plant and operated during 1905; but the production of electricity by steam was too expensive, and in 1906 the mill was moved to Yorkhaven, Pa., where electricity generated by water power could be had. This company reports a production of about 500 pounds a day and a capacity of about 1,200 pounds.

At the census of 1900, three establishments were reported in operation, but at the 1904-5 census only the Oldbury Electro-Chemical Co., of Niagara Falls, reported.

In addition to the domestic production, the United States imports annually from 30,000 to 40,000 pounds of phosphorus, on which a duty of 18 cents a pound is paid. The price in the New York market ranges, according to quality, from 45 to 70 cents a pound.

The same pamphlet contains a paper by Myron L. Fuller on the production of phosphate rock. The production in the United States has increased from 1,947,190 long tons (\$6,763,403) in 1905 to 2,080,957 long tons (\$8,579,437) in 1906. Phosphate rock is used altogether in the manufacture of artificial fertilizers and chemicals containing phosphoric acid.

Notes on Electrochemistry and Metallurgy in Great Britain.

(From Our London Correspondent.)

THE BRITISH ASSOCIATION MEETINGS AT LEICESTER.

While the ordinary fortnightly or monthly meetings of the various scientific societies have an intermission of from four to six months during the summer, the actual activity of paper reading and discussion bursts out here and there during the nominally holiday months. This activity began this year with the Iron and Steel Institute meetings, then came the triennial engineering conference of the Institution of Civil Engineers, with its multifarious subject matter. Then followed the Dundee meeting of the Institution of Mechanical Engineers and the British Association meeting at Leicester. In September there will be the Iron and Steel Institute Autumn meeting in Vienna. Technical "copy" therefore has been unusually plentiful.

Of course, the British Association papers dealt with a large number of different subjects. Prof. Silvanus Thompson's presidential address to the Engineering Section was partly an historical review and partly a philosophic discussion of the education and training of the engineer. The papers dealt with questions in abstract physics, such as the "Constitution of the Atom," the "Density of the Ether," etc., laboratory phenomena, such as radio-activity, and matters more closely related to dividends, such as a paper on gas and petroli engines, or on metallic filament lamps, or on rail corrugation, or on the effect of ice in Canadian hydroelectric installations.

RAIL CORRUGATION.

Of directly metallurgical interest was Mr. Worby Beau-

mont's paper on "The Origin and Production of Corrugation of Tramway Rails." The following are the author's conclusions:

1. The compression of the material of the table of the rail by the tramcar wheels; cold rolling.
2. The microscopic deformation of the surface of the rail on the small area of contact between wheel and rail, that deformation being attended by a depression under the wheel.
3. That the material of the surface in front of the wheel and the depression recurrently form a slight ridge of unassignable height, over which the wheel mounts.
4. That the area of contact between wheel and ridge is minute, and the pressure, therefore, very great per unit of area, and hence the severe pressing of the ridge into the material of the rail table and its hardening or its crushing.
5. That the distance between each ridge thus formed by the rolling wheel will vary slightly with the strength, hardness and toughness of the rail, and with the speed of the car wheels.
6. That the originating ridge forming the incipient hard patch is added to, on the formative or rear side, thus gradually extending from a more transverse line to an area of increasing length.
7. That the hard patch thus formed for a time resists the destructive deformation by the wheel, but that it increases the rate of local side detraction, and that the extruded material is in some positions of the rail worn off by the flanges of the wheels, which are thereby pushed laterally against the other side of the rail groove, and make more or less distinctive marks therein.
8. That a steel rail loses a large part, if not most, of its weight in wear by the separation of the compressed and crushed surface by minute exfoliation, the surface film exceeding the dimensions of the sub-surface, and separating itself by disintegration, flaking or crumbling, as shown by pitting.
9. That this disintegration of the surface partially relieves the surface film of the destructively compressed parts and the sub-surface of the corresponding tension.
10. That the hard, bright patches depend for their duration upon the strength of their supporting materials, and in many cases should disappear, though they reappear in different position.
11. That the appearance of the hard patches on the outer curves of some lines where none appear on other of the rails of the same line is due to the heeling over of the cars on the curve and the extra weight thereby put on the outer wheels on this outer curve.
12. That it is possible that the final passes of some rails through the rolls at a comparatively low temperature may produce a condition in the rail conducive of initiation of corrugation, and thus accessory before the rail is laid.
13. That there are numerous circumstances and conditions in the working life of a tramway rail which produce great contrariety in results, including (a) its correct laying, which causes a greater or lesser width of the table to present itself to the wheel thread; (b) the grinding slip of the propelling wheels on one side of the car affected by the condition of the rail surface and by the heavier load on the outer rails on curves, causing or permitting the wheels on the inner rails to slip; (c) the speed of the cars; (d) the character of the dirt and grit on the rails, the construction of the rail, etc.
14. The remedy appears to be: (1) lighter cars; (2) harder rails; (3) moderate speeds and larger wheels.

HELIUM AND RADIO-ACTIVITY IN COMMON ORES AND MINERALS.

The Hon. R. J. Strutt's paper on this subject pointed out that it had now been recognized that the origin of the presence of helium in many minerals was due to the radio-active changes, and the object of his recent investigations had been to see if helium can be found in certain common minerals which are not known to contain even traces of radio-activity. He had been able to find traces of helium in almost all metalliferous ores and strong minerals. Concurrently with the helium determination the quantity of radium was also determined by well-

known methods, and it was found that the quantity of radium present is in almost all cases sufficient to explain the helium without postulating its production with the small radio-activity, which there has been reason to associate with common elements.

MODERN MACHINERY AND ITS FUTURE DEVELOPMENT.

Mr. H. I. Brakenbury's paper was chiefly devoted to giving an account of the factors which have tended to make machine tools develop on certain lines, and to showing that there were forces now at work which might considerably alter our views and ideas as to the value of certain classes of machinery. In dealing with the efficiency of automatic turning machines compared with those worked by hand, he gave a number of curves of costs, taking into account wages, rate of output, cost of machine, cost of tools and setting up, and cost of material. The conclusion was that automatic machines show a saving when the capital cost is not more than £250 each. After this figure a loss is shown, which increases very rapidly. He thought that the large automatic machine was a creation of the past, and that the future would bring no further development in this direction. The simple automatic machines of small size were of the greatest value. The complicated machines for work requiring many short operations were not economical.

Passing on to grinding machinery, Mr. Brakenbury spoke of the great improvements which had been made in the direction of increased speed of removing material, but said that he did not think that finality had been reached. He referred to a new feature which was being introduced in the form of an automatic sizing arrangement, which automatically changed the feed from roughing to finishing, and knocked out the feed when the finished side had been obtained quite independently of the wear of the wheel. Another tool to which he thought there was a great future was the screw milling machine.

THE MEASUREMENT OF THE FORCES ON A CUTTING TOOL.

Mr. J. F. Brooks described "A Machine for Weighing the Forces on a Cutting Tool," the object of which is to measure the three co-ordinate components of the force on a cutting tool while in the act of cutting metals. The tool, fixed in a holder, forms part of a simple lever, carried by a thin diaphragm of steel. This device gives a universal frictionless pivot when used for very small displacements. The location of the lever is effected by means of electrical contacts in circuit with telephone receivers. Weights are used to balance the forces. The apparatus is capable of measuring maximum, minimum, as well as mean values. The position of the center of pressure may be found by two or more experiments. The paper was illustrated by diagrams, showing the value of the forces on tools with cutting angles of 65° and 70° when cutting cast iron and mild steel, with small cuts at moderate speeds.

THE PROSPECTS OF THE ALUMINIUM CORPORATION, LTD.

A recent statutory meeting of the shareholders of the Aluminium Corporation, Ltd., afforded the chairman, Sir James Sivewright, an admirable opportunity of outlining the contemplated activities of this undertaking. He pointed out that the company was formed according to the prospectus, which was to acquire certain freehold property and water rights of a place in North Wales for the development and production of aluminium. The original idea was to lease the premises, but after consideration the directors thought that it would be far more economical to obtain the freehold of the buildings, and they had paid the sum of £55,000 for the freehold rights. The extent of the premises was 1,300 acres, which included the area of Lake Eigure, which covered 86 acres. They also received a rental of £528 for land, and they had no doubt that that land would considerably increase in value in the future. The works at present were in active course of construction, and according to the terms these works were to be completed in twelve months, and the whole of the undertaking in two years. Desirous as they were of getting power as

quickly as possible, they had made arrangements with the North Wales Electric Power Co. for the supply of 600 kw., at a price which they considered very satisfactory. After consideration the directors had increased that supply to 1,200 kw., or 1,600 hp., so that instead of having 6,000 hp. available as stated in the prospectus, they would have, when all the works were completed, nearly 7,000 hp. available. Having in their minds that it was the best thing to get the cheapest way of producing the metal, the company had made arrangements with the Newcastle Electric Supply Co. for a supply of current for power purposes at Tynemouth. They hoped to get from that some 4,000 kw. per annum at a price which they considered satisfactory. The directors had secured a plot of land almost adjoining the works of the electric company, and the construction of the buildings was now going on. If the North Eastern Railway Co. fell in with their idea as regarded price they hoped to have a railway siding built alongside of the works, which would be of great advantage. As to raw materials, they had entered into contracts which would come into effect as soon as they were capable of producing aluminium. He saw no reason why they should not be in a position to turn out the metal at the end of this year or early in 1908. They did not anticipate any drop in the somewhat high prices which now ruled for the metal. The demand was largely in excess of the supply, and the merits of the article were such that they had no doubt that their company would be a prosperous concern. The field for aluminium was so large that he thought the shareholders in that company had good prospects in the future.

AN ELECTRICALLY-CONTROLLED SINGLE LEVER TESTING MACHINE.

The Aberdeen meeting of the Institution of Mechanical Engineers had one paper only before them, which was metallurgical in its nature, namely, that by Mr. C. E. Larrard, on the above subject. The machine in question has been installed at the mechanical engineering department of the Northampton Institute.

The remarkable control obtained in this machine for torsion as well as the more usual tests of tension, compression and bending, is due to the use of two electric motors with wide-speed ranges, the high range in the rate of straining by hydraulic pressure, and the fact that the handle and other adjustments are controlled from one position. These and other special features, together with an efficient chronograph for indicating the time intervals during straining and loading, will, the author believes, enable fresh investigations on the strength and properties of material to be carried out.

The machine is one of Mr. Wicksteed's vertical single-lever machines, with a low-lever ratio, satisfying in every respect the requirements of the Board of Trade. A maximum stress of 150,000 pounds can be impressed on the specimen for tension, compression and bending, while torsion tests can be made on short specimens up to a moment of 400,000-inch pounds. The poise weight, which can be given two values, is under electrical control in either direction, or hand-driven when required. The straining for tension, compression and bending is, as usual with these large machines, effected by hydraulic pressure, while for torsion the twist is put on by means of an electric motor.

MARKET PRICES DURING AUGUST.

In the chemical trade sulphate of ammonia is 2s. 6d. per ton fitter at £11.17.6. The coal tar products are unchanged. Copper sulphate has receded from £31 to £27 per ton in sympathy with the fall in the price of copper.

The soda products are unchanged.

As regards metal prices, the copper situation has been unchanged. The fall commencing at £96 per ton on July 24, which had reached £86.15 per ton on Aug. 1, continued until Aug. 13, when £76 was touched. Thereafter followed irregu-

larities, including a rally to £79 on the 21st, a fall to £77 on the 26th, with a final closing on Aug. 30 of £76.7.6 and a general reticence on the part of consumers to buy for immediate needs only. There are signs, however, of returning confidence and of a tendency to cover future requirements.

The movements of tin prices have been rather startling. Opening at £180 on Aug. 1, prices fell to £165 on Aug. 14, rallied to £169 on Aug. 16, fell to £166 on the 22d, rose to £170.10 on the 27th, and closed at £169.

Lead has been fairly firm, opening at £20.5 per ton and closing at £20, the highest price being £20.10 on Aug. 14.

Cleveland pig iron has been very steady, opening at 57s. 3d.

per ton and closing at 56s. 4½d. Hematite has been well maintained, opening at 78s., touching 79s. on the 7th and 78s. on the 15th, and closing at 80s.

Antimony is fetching £38 per ton and platinum £5 per ounce. Steel rails and plates are firm at £7.12.6 and £6.15, respectively.

Stocks are low, and the present activity seems likely to be of continuance. Shipbuilding—save for orders for warships—has perceptibly slackened, but foundries and rolling mills are full of work. The hardening of the price of fuel is somewhat disturbing.

LONDON, Sept. 3, 1907.

ANALYSIS OF CURRENT ELECTROCHEMICAL PATENTS

ELECTRIC FURNACE.

Regulating the Iron Reduction in an Electric Furnace.—

P. L. T. Héroult, 861,280, July 30, 1907. Application filed April 25, 1906. Assigned to Société Electrometallurgique Française.

In smelting iron ore in a furnace with one vertical electrode, while the crucible below forms the other terminal, it is possible by adjusting the quantity of lime added to the charge to produce a thinner or thicker scale or lining upon the side walls of the furnace in the fusing zone. If more lime is added than is necessary to maintain the composition of the slag, the excess lime forms a scale or lining. On the other hand, to diminish the thickness of this scale, it is only necessary to supply less lime than the slag requires, whereupon the slag will dissolve the scale until its equilibrium is restored. By adjusting the thickness of this scale it is possible to diminish or enlarge the cross-section of the zone of fusion, thus concentrating more or less the energy density in the fusion zone. If the cross-section is reduced and the energy density increased, the electrode is lifted by the usual automatic mechanism which maintains the voltage and current constant. The increase in the length of the zone of fusion then increases the rate of reduction in this zone and produces a pig of higher silicon content. The reason given by Dr. Héroult is that when the electrode is raised the incandescent carbon column becomes longer, and this added resistance enables the arc (which extends from the lower end of the electrode to the top of the carbon column) to become a little shorter. Consequently there is less heat for the melting of the oxide of the charge, and the operation of the furnace is less rapid, but the oxides which are melted pass through a long column of carbon and are more completely reduced. Since it is at least approximately true that the iron is first reduced and then the silicon, it follows that the elongation of the zone of fusion produces an increased silicon content in the product. Therefore by increasing the thickness of the scale, the silicon content of the product is increased, or by decreasing the thickness of the scale, the opposite effect is obtained.

Steel Refining.—P. L. T. Héroult, 851,167, April 23, 1907. Application filed April 28, 1906. Assigned to Société Electrometallurgique Française.

To refine a metal, Dr. Héroult prepares a bath of it and oxidizes it to such an extent as to transfer the impurities from it to the slag while maintaining its melting point below the temperature of the furnace, so that it remains liquid until the transfer of the impurities is substantially complete. The metal is then solidified, while the slag is maintained molten and the slag with the impurities is removed, after which the metal is remelted and treated as desired to obtain the final composition.

For the purification of steel either in an open-hearth furnace or in an electric furnace the following special notes are given:

It is assumed that a basic open-hearth furnace of the tilting type is used. The fusing point of steel or iron varies with the composition, increasing with the purity of the metal. Crucible steel (containing, say, 1 per cent of carbon), for example, fuses at approximately 1,400° C. As the carbon is reduced, we have soft steel of, say, 0.10 per cent carbon, which fuses at approximately 1,600° C. Substantially pure iron (deoxidized) fuses at approximately 1,900° C. If, however, the iron of substantial purity (containing, say, 0.01 per cent carbon, 0.01 per cent of phosphorus, and 0.015 per cent sulphur) be over oxidized, its fusing point is reduced. When it contains, roughly, about 0.75 per cent oxygen, its fusing point is lower than that of soft steel, both of these being well within the temperature attainable in a Siemens furnace. The present invention utilizes these variations in the fusing point, and it is assumed that the temperature of the furnace throughout the process is maintained above the fusing point of soft steel and below that of pure iron deoxidized. According to the present invention the oxidation of the bath is continued not only until the desired percentage of the carbon has been oxidized, but beyond this point until substantially pure iron superoxidized is obtained. In this superoxidation substantially the whole of the impurities are transferred to the slag. The pure metal is then deoxidized, so that its melting point is quickly raised above the temperature of the furnace. It solidifies as soon as it is sufficiently deoxidized, and we thus have in the furnace a solid base of deoxidized pure iron very smooth on its upper surface, and upon which there is a molten slag which can be readily removed, carrying with it the impurities which have been extracted from the iron. It is for the purpose of dumping the slag that a tilting furnace is advantageous. The surface of the iron is so smooth that the slag may be removed almost to the last drop. The impurities being withdrawn, the pure iron may be converted into steel of any desired composition. For example, to make soft steel or crucible steel, both of which fuse at the temperature of the furnace, it is only necessary to add carburizing materials, such, for example, as carburite (a mixture of carbon and iron) or pig iron of high purity. A neutral slag is also applied to the surface of the metal to protect it from the oxidizing action of the flame. The continuance of the process will be in accordance with the usual practice, and depend upon the product desired, which may, for example, be basic open-hearth steel of high purity.

The raw material may be ordinary scrap, which is melted down and oxidized by the flame and by the ore usually added. The bath may be fed with additional scrap or pig, only taking precautions not to deoxidize it. After the bath is well melted and superoxidized, the deoxidation may be effected by adding pig, the conditions being continued until the freezing occurs. Any neutral slag may be used for the last stage of the process, such, for example, as lime, sand and clay, or other materials which will be fluid and protect the metal from the flame. The slag is not expected to exert any chemical effect on the steel.

inasmuch as there is nothing to be removed therefrom. After the final melting of the steel it may receive the usual additions of manganese, silicon, aluminium, or the like, to ensure the casting of sound ingots as far as possible. By this process steel of very high purity may be obtained from very poor or impure stock.

Low Carbon Ferro-Alloys.—E. F. Price, 865,609, Sept. 10, 1907. Application filed Nov. 14, 1905.

The inventor produces low carbon ferro-chromium, ferro-manganese, ferro-titanium, ferro-vanadium, etc., by the use of ferro-silicon as reducing agent. In the first stage of the process, therefore, ferro-silicon, high in silicon and low in carbon, is produced, by electrically smelting a charge of silica, iron ore or iron and carbon. The molten silicide is tapped from the smelting furnace and allowed to solidify. The ingot is then broken into fragments which are mixed with a granular body of the compound to be reduced, for example, chromite, and the mixture is melted in an electric furnace, the charge serving as resistor, with the use of a basic flux, such as lime.

Vanadium, Ferro-Vanadium, Etc.—F. M. Becket, 866,561, 866,421 and 866,562, Sept. 17, 1907. Applications filed Dec. 22, 1906, Jan. 31, 1907, and June 12, 1907, respectively. Assigned to Electro Metallurgical Co.

Patent 866,561 refers to the production of ferro-chromium, ferro-tungsten, ferro-vanadium, etc., by means of ferro-silicon as reducing agent. Fifty per cent ferro-silicon is preferably used, and a basic flux is employed to combine with any excess of silica which may be present in the ore and with the silica derived from the oxidation of the silicon. If the alloy shall be of very low silicon content, slightly less ferro-silicon is used than is necessary for the complete reduction of the ore or concentrate. The process is carried on in a continuous operation, the current passing through a molten bath of a mixture of ore, ferro-silicon and basic flux, and when metal or slag has been withdrawn additional quantities of the mixture are added. It is advantageous to feed the mixture to a bath which is maintained at a temperature higher than is necessary to cause some reaction.

Patent 866,421 relates to the reduction of oxides of vanadium, molybdenum, etc., in two steps. The first step is the partial reduction to a lower oxide by means of carbon or producer gas or water gas, etc. Vanadic oxide, for instance, is reduced by means of carbon, according to the equation $V_2O_5 + 2C = V_2O_3 + 2CO$. The second step is the reduction of the lower oxide to the metallic state in an electric furnace with silicon, ferro-silicon or aluminium as reducing agent. This final reduction, using either silicon or aluminium, is represented by the equations $2V_2O_3 + 3Si = 4V + 3SiO_2$ and $V_2O_3 + 2Al = 2V + Al_2O_3$.

According to patent 866,562, vanadium ores, for example, oxides or roasted sulphides or concentrates are reduced in the presence of iron, preferably by the use of silicon, aluminium, etc., the products being commercial ferro-vanadium and a slag containing compounds of vanadium, silicon, etc. The slag is then smelted in the presence of iron and an excess of a reducing agent, to wit: aluminium, silicon, etc., or when the slag contains compounds of both vanadium and silicon, sufficient carbon or calcium carbide to reduce both of these metals. The product of this second step is ferro-vanadium containing aluminium, if the latter was employed as reducing agent, or silicon, etc. The ferro-vanadium containing silicon or aluminium is then smelted with a vanadium ore or concentrate, whereby a further quantity of vanadium is produced and the silicon or aluminium is eliminated, the products being commercial ferro-vanadium and a slag containing vanadium. This slag from the third step is then smelted in the presence of iron in the same manner as described for the second step. In practice the second and fourth steps of the process may be combined.

Manganese Silicide.—E. F. Price, 866,597, Sept. 17, 1907. Application filed Nov. 14, 1905. Assigned to Electro Metallurgical Co.

A charge of compounds of manganese and silicon is smelted in an arc furnace, carbon being added to the charge in sufficient amount to not only reduce the manganese and silicon but also to protect the carbon electrodes from oxidation. A considerable body of the charge is maintained around the depending electrode or electrodes, and the reduction, withdrawal of the product and supply of the charge mixture are conducted as a continuous operation. The potential difference between the electrode terminals is kept at the minimum value requisite for the maintenance of an arc, to prevent leakage of current through the charge.

Calcium Carbide and Phosphorus.—J. T. Morehead, 862,092 and 862,093, July 30, 1907. Application filed Oct. 14, 1895. Assigned to Willson Laboratory Co.

Calcined bones or phosphate rock are treated in an electric arc furnace to produce simultaneously phosphorus and calcium carbide. One hundred pounds of phosphate rock, consisting chiefly of tricalcic phosphate, are mixed with 55 pounds of coke or charcoal and 8 pounds of lime, and are finely ground. The mixture is treated in an electric arc furnace through which a reducing hydrocarbon gas is passed. The reaction is



The phosphorus distills over and is won in the condenser F,

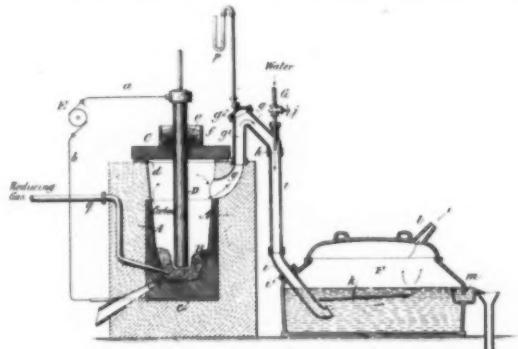


FIG. 1.—ELECTRIC FURNACE FOR PRODUCTION OF CALCIUM CARBIDE AND PHOSPHORUS.

while the carbon monoxide passes off through 1. The calcium carbide won in this process is not pure but is a phosphoric or phosphorized calcium carbide. The phosphorus exists in the form of calcium phosphide, which is intimately combined with the carbide. In contact with water both acetylene and phosphorus are liberated. The latter is ignited spontaneously by the heat of combination and burns to phosphoric acid. The phosphorized carbide is therefore a very dangerous substance to handle or store, but is useful for special purposes, for instance, for illuminating a distant point on a body of water at night. A cartridge or shell charged with this material might be fired from a gun under such conditions as to liberate the material on striking the water. The carbide would then instantly begin to generate acetylene gas, which would be ignited by the phosphide, and if the mass were made to float the reaction would continue until all the carbide was decomposed, so that a brilliant illumination could be maintained for a considerable time.

Manufacture of Electric Resistance Bodies.—F. Bölling, 864,723, Aug. 27, 1907. Application filed Dec. 29, 1904. Assigned one-half to Chem.-Elec. Fabrik Prometheus.

Carborundum or carbide of boron or silicicon or similar materials are converted into a coherent mass suitable for resistance bodies, at a temperature below their melting point. This may be done in a suitable electric resistance furnace, the

product obtained being of a porous nature. In order to increase the mechanical strength of the bodies they may be dipped in enamel and then fired in a suitable furnace. This secondary treatment may in certain cases be avoided by adding to the finely pulverized raw material, suitable materials for the purpose of still more firmly cementing the crystals together, for instance, artificial corundum, or a similar material having a high fusing point. The addition of any of such materials has, however, the disadvantage that the fusing point of the resistance bodies is reduced. By an addition of 10 per cent corundum the fusing point is reduced to about 1,500° C. A further disadvantage of such binding materials is that the resistance in most cases becomes too high for some purposes. A specially suitable resistance body is obtained by the addition of boracic acid, which serves simultaneously as a deoxidizing agent and binding material and for the increase of conductivity. The boracic acid is added to the carbide or mixture of carbides, and the mass is pressed together under strong pressure and finally fired at a temperature of about 800° to 1,200° C., but below its melting point. "In a test 9 grams of crystals of silicon carbide and 1 gram of boracic acid were mixed together, the mass then pressed and fired at about 1,200° C. The product showed such a good conductivity that a body of 80 mm. length and 8 x 8 mm. section could be utilized for a tension of 72 volts." Resistors made in this way may be used for starting or regulating resistances, as resistances for arc lamps, as heating resistances, etc. These resistance bodies, made with boracic acid, can be applied for temperatures up to 800° C., but at higher temperatures they become soft, so that in this respect they are inferior to those made of carbide without binding material or with a silicified carbon bond. On the other hand, they possess the important advantage that for their production much cheaper raw materials can be employed, because the amorphous carborundum which is used is obtained as a by-product.

Heating Bar for Electric Oven.—A. L. Brougham, 857,381, June 18, 1907. Application filed Oct. 26, 1906.

In electric heaters and ovens heating bars are sometimes used, the central part of which has a high electric resistance and is brought to incandescence by the current, while the terminal portions have a higher electric conductivity and are therefore heated to a smaller degree. The present inventor makes the terminals of 70 per cent carbon and 30 per cent clay, and the central portion of 30 per cent carbon and 70 clay. The terminals are interdigitated, as shown in Fig. 2, which represents a plan and side view; 1 and 2 are the terminals and 3 is the heating portion. These members are interdigitated end to end at A. The digitations in the terminals are in

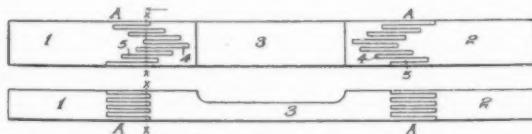


FIG. 2.—RESISTOR CONSTRUCTION.

the form of rectangular bars 4 projecting from the bodies of the terminals and meshing with corresponding digitations 5 projecting from the ends of the central portion 3. The digitations are arranged in a series of vertical rows of uniform length. The rows are disposed in echelon in such a manner that the digits of the terminals extend gradually further and further into the heating portion of the bar from the sides to the middle. Thus the resistance of the bar, considered as a whole, is caused to increase gradually between the body of the terminal and the body of the heating portion, thus avoiding altogether abrupt gradations in the heat of the bar with consequent liability to rupture and injury, due largely to unequal expansion. The entire bar is molded and is built up from

several layers, each of a depth or thickness equal to that of its digitations.

Resistors for Electric Heating.—G. Egly, 866,444, Sept. 17, 1907. Application filed Dec. 2, 1905. Assigned to Gebrüder Siemens & Co.

A mixture of silicon and carborundum is pressed into the desired form. An agglutinant may be used which is either completely volatilized by the high temperature to which the form is afterwards subjected, or completely or partially left in the mass, for instance, an agglutinant which is carbonized when heated, such as tar or the like. The fashioned form is then heated in an atmosphere of pure nitrogen, whereby the silicon combines with nitrogen and the silicon nitride cements the particles of carborundum strongly together. When an agglutinant that is capable of being carbonized is used, there is formed, according to the proportion of the carbon thus introduced a compound of the composition C_2Si_2N . If a proportion of carbon corresponding with this formula be added to the silicon, there is obtained a very solid mass, which conducts well and consists in the main of the compound C_2Si_2N ; this compound, like the silicon nitride, firmly cements the carborundum.

Articles produced in this way can be heated in the open air to temperatures as high as 1,000° C. without being changed in the slightest degree. They are remarkably dense and hard, and may be used for grindstones, etc. Finally, on account of their electric conductivity they may be used as electric heating bodies. "A rod, consisting of C_2Si_2N , as described above, 125 cm. long and 1 sq. cm. in cross-section, has an electrical resistance of about 1 ohm. If the rod be fashioned from a mixture of 70 parts of silicon carbide and 30 parts of silicon and be heated in nitrogen in the manner described, it will have for the above dimensions a resistance of about 20 ohms. If the mass consists of 70 parts of silicon carbide and 30 parts of silicon be mixed with 10 parts of clay, a rod of the same dimensions will have a resistance of about 70 ohms. On the other hand, if silicon carbide were mixed with 10 per cent of clay without any silicon and burned in the ordinary manner, the form produced would have a very high resistance, namely, about 1,000 ohms, and mechanical properties much inferior to those of the forms made with aid of silicon and nitrogen."

Electric Muffle Furnace.—A. L. Marsh, 861,744, July 30, 1907. Application filed Feb. 18, 1907. Assigned to Hoskins Co.

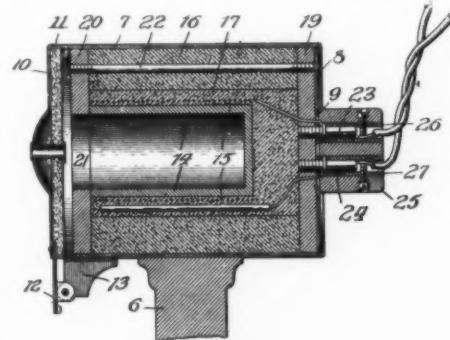


FIG. 3.—MUFFLE FURNACE.

The construction is shown in Fig. 3. The muffle consists of an inner tube 14 of fused magnesia or similar refractory material, about which is coiled a conducting wire 15 of a high electrical resistance and special construction; 16 is a tubular shell of fire-clay, and between the two tubes silica or another material which does conduct the heat is packed. A disc 19 of asbestos fiber closes the inner end of the muffle and the disc 20 covers the outer end. The latter has a central opening 21 which forms the mouth of the muffle. Rods 22 fasten the discs 19 and 20 in place. (The commercial form of

this furnace is described in an article on another page of this issue.)

Induction Shaft Furnace.—J. S. Edström, 862,146, Aug. 6, 1907. Application filed March 30, 1906.

The diagrams of the furnace, Fig. 4, are almost self explanatory. The lower diagram is a horizontal section on line II, II, while the upper right-hand diagram is a vertical section along the line III, III; 4 is an iron core, and on it is

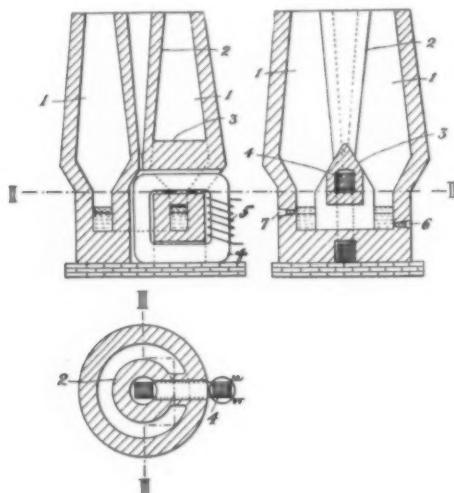


FIG. 4.—INDUCTION SHAFT FURNACE.

wound the primary winding 5 which induces an alternating flux in the core. The fused bath represents the secondary, 7 being the tap-hole for the slag and 6 for the metal. The ores which are smelted are heated on their passage downwards by the uprising gases, and any carbon monoxide gas may be burned in the shaft above the zone of reduction by application of an air blast.

Electric Furnace.—W. G. Clark, 865,016, Sept. 3, 1907. Application filed Dec. 17, 1906. Assigned to Electric Furnace Co., of Portland, Me.

A graphite crucible, has a rounded bottom, and within it is placed a central electrode, also of graphite, which is shaped to fit the bottom and to have for the greater part of its length a higher resistance than its foot and than the furnace walls. For this reason the main stem of the electrode is made relatively thin. The furnace is started by removing the electrode from the bottom of the furnace and thus producing an arc. After the melting has begun the electrode is again brought into direct contact with the furnace walls, and the furnace is operated as a resistance furnace. It seems to be intended for the manufacture of glass.

Electric Smelting Apparatus.—J. C. Young, 865,285, Sept. 3, 1907. Application filed Jan. 16, 1907.

The first claim reads as follows: "In an electric smelting apparatus, a carbon forming one pole and a series of spaced receptacles mounted for rotation in a vertical plane and forming the other pole, whereby an arc is adapted to be established or interrupted between said receptacles, one at a time, and the carbon."

Electric Furnace.—H. N. Potter, 851,961, April 30, 1907. Application filed July 23, 1903.

The claims of this patent refer to the construction of an electric furnace, the corresponding method patent having been already abstracted in our Vol. III, p. 346. The furnace is essentially a combination of an electric tube furnace and an arc furnace.

ELECTROLYTIC PROCESSES.

Production of Alloys from Fused Salts.—F. von Kügelen and G. O. Seward, 865,648, Sept. 10, 1907. Application filed May 26, 1905.

When a fused mixture of two salts of different metals, but with the same anion, is electrolyzed the less electro-positive metal is separated before the more electro-positive metal. With salt mixtures having different anions, the decomposition voltage of each salt becomes the determining factor. If the salt of the less electro-positive metal has the higher decomposition voltage, the other salt will be decomposed first and its anions set free at the anode. Its cation, that is the more electro-positive metal, will enter into a secondary reaction with the anion of the less electro-positive metal; but this secondary reaction is in general not complete, and the result at the cathode is in most cases the deposition of an alloy of both metals. When a fused mixture of $MgCl_2$, $NaCl$ and KCl , containing about 13 per cent Mg , is subjected to electrolysis, pure magnesium is obtained. When, however, most of the $MgCl_2$ is replaced by MgF_2 , keeping all other conditions the same, an alloy of magnesium with alkali metals instead of pure magnesium is deposited. Electrolyzing a mixture of MgF_2 and $CaCl_2$ results in an alloy of magnesium and calcium with constant separation of chlorine at the anode. The explanation by the authors is as follows: $NaCl$ requires for its decomposition 4.3 volts, MgF_2 requires 4.6 volts, and NaF requires 4.7 volts. Sodium chloride is decomposed first, its decomposition voltage being lower than that of the MgF_2 , and the MgF_2 is in turn reduced by the sodium, though this secondary reaction is not complete, because the heat of combination of $2NaF$ is only a little higher than that of MgF_2 . The result of electrolyzing a mixture of MgF_2 and $CaCl_2$ is similarly explained, the $CaCl_2$ being decomposed before the MgF_2 , and the MgF_2 being reduced in a secondary reaction by the nascent calcium. The secondary reaction is not complete because the heat of combination of CaF_2 is only slightly higher than that of MgF_2 . An alloy of magnesium and calcium is therefore obtained. The authors use this principle for "the production of alloys

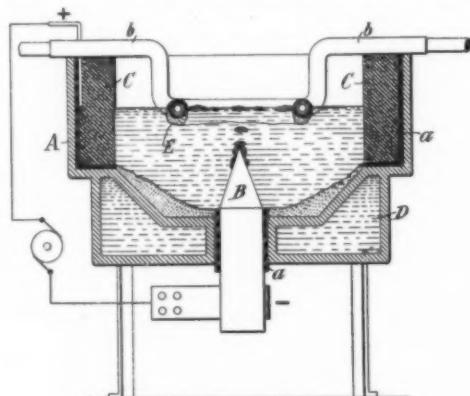


FIG. 5.—CELL FOR CALCIUM PRODUCTION.

from a molten mixture of salts by selecting a compound of the less electro-positive metal having a higher decomposition voltage than the compound of the more electro-positive metal, and so regulating the electrolytic conditions that the secondary reaction between the more electro-positive metal (which is set free first) and the compound of the less electro-positive metal is not complete, but takes place only to the extent necessary for the formation of the desired alloy.

Electrolytic Production of Metallic Calcium.—G. O. Seward and F. von Kügelen, 864,928, Sept. 3, 1907. Application filed April 25, 1906. Assigned to Virginia Laboratory Co.

The principle is to separate the calcium with a high cathodic current density at a high temperature in molten state, and then

remove it quickly from the hot zone around the cathode into a cooler portion of the electrolyte, since the reduction of its temperature diminishes the danger of the redissolving of the calcium in the electrolyte. The construction of the cell is shown in Fig. 5, where A is a cast iron vessel, B is the cathode of iron or steel, and C the annular graphite anode. The cathode and anode are separated from the iron vessel by layers *a* of insulating material like asbestos. With the aid of the water jacket D the bottom and exposed portions of the vessel are protected by a chilled layer of the electrolyte. Above and concentric with the cathode B is arranged a water-cooled collecting ring, which chills upon its surface a sufficient layer of the electrolyte to protect it. For this purpose water is circulated through the pipes *b*. The electrolyte is calcium chloride. The high current density at the cathode causes calcium to be formed in molten globules, which, when they become large enough detach themselves from the cathode and flow to the surface, where they collect within the confining ring and cohere into a mass of constantly increasing volume and of sufficient firmness to be readily removed. The metal is cooled to such an extent that it does not burn by contact with air. From time to time fresh calcium chloride in molten and completely dehydrated state is added. Chlorine is, of course, evolved at the anode.

Copper or Lead From Sulphides.—E. L. Anderson, 862,871, Aug. 13, 1907. Application filed Feb. 23, 1907.

In order to reduce copper or lead sulphides the cell shown in Fig. 6 is used with the electrodes 2 of carbon and an electrolyte E of hydrofluosilicic acid H_2SiF_6 . The sulphide ore O to be reduced is placed between one electrode and the perforated wooden diaphragm 3, which is covered with the linen or canvas sheet 4, so as to permit the circulation of the liquid, but intercept the fine particles of the ore. Current is then

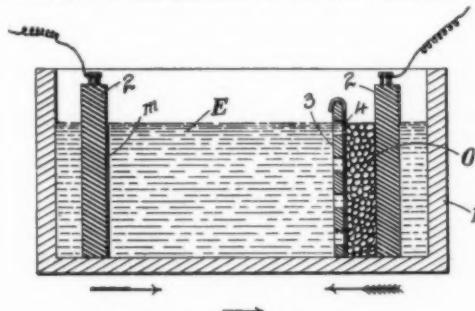


FIG. 6.—REDUCTION OF SULPHIDES.

sent through the cell from the left to the right, so that the sulphide ore in contact with the carbon plate acts as cathode, and by cathodic reduction the sulphur in the ore combines with hydrogen and sulphuretted hydrogen is given off. After all the sulphide has thus been reduced the current is reversed and the copper now goes into solution as $CuSiF_6$, and is then deposited as a pure copper sheet M on the other electrode. An advantage of the electrolyte used (for instance, over sulphuric acid, which is employed in the similar Salom process) is said to be that the electrolyte dissolves only the metals to be recovered while it has little affinity for ferric oxide and sulphide. If they are contained in the ore they are not reduced by the nascent hydrogen, and will not pass subsequently into solution, but will precipitate themselves in an insoluble form to the bottom of the tank.

Electrolytic Production of Copper from Ores.—R. Lamb, 852,438, May 7, 1907. Application filed Dec. 22, 1902.

According to claim 1, the process consists "in reducing the ores to granular condition, then placing said ores within a closed leaching vessel, then introducing water and placing liquid SO_2 into said vessel whereby free sulphurous acid will be formed and a solution of the copper thereby effected, then

pneumatically separating said solution from the residue, then washing said residue and preserving said washings, then subjecting said solution as an electrolyte to a current of relatively low density between insoluble anodes and cathodes maintaining an excess of sulphurous acid in said electrolyte whereby the same will be oxidized to form free sulphuric acid, then re-employing said electrolyte depleted from copper for leaching fresh charges of ore."

Gravity Cell.—G. Rambaldini, 861,226, July 23, 1907. Application filed Jan. 28, 1902.

The anolyte and catholyte of a double-fluid electrolytic cell are held separate from each other by means of a solid impermeable partition. The necessary electric connection between the two solutions is made by means of a third solution of much lower specific gravity than the other two and placed on top of the other two. The arrangement is essentially the same as in the inventor's former patent, which was abstracted in our Vol. III, page 112.

Electrolytic Apparatus for Reduction of Metals.—C. E. Robertson, 861,319, July 30, 1907. Application filed July 30, 1906.

The chief features of the inventor's "electrolytic furnace" are that the cathode is formed by a crucible with an interior lining of carbon while the anode consists of vertical carbon tubes suspended from a disc which is revolved during electrolysis to provide stirring and prevent the surface from freezing.

Electrolytic Production of Glycolic Acid.—O. Liebknecht, 837,083, Nov. 27, 1906. Application filed June 14, 1906. Assigned to Roessler & Hasslacher Chemical Co.

Oxalic acid in sulphuric acid or hydrochloric acid solution is reduced electrolytically nearly quantitatively and with very good current yield, if electrodes having a high cathodic overvoltage—such as a lead electrode—are used together with a diaphragm to separate the anodic and cathodic liquors. The cathodic liquor is to be stirred during electrolysis, and care has to be taken that not too dilute acid is used. The following instructions are given: 700 parts of crystallized oxalic acid are dissolved in about 3,300 parts of water, and 1,100 parts of 30 per cent sulphuric acid are added while stirring. This solution forms a cathodic liquor, which it is of advantage to keep warm during the process of electrolyzation. The cathodic liquor should be placed in the cathodic compartment of a suitable electrolytic apparatus provided with a suitable diaphragm, and the anodic liquor, comprising a 30 per cent sulphuric acid is placed on the other side of the diaphragm. The density of the current at the cathode may vary greatly, for instance, from 25 to 250 amps. per square meter of surface of cathode. The presence of the diaphragm in connection with the use of a not too dilute acid largely prevents the anodic oxidation of the oxalic acid. On completion of the electrolysis the anodic solution may be used in preparing a fresh charge of the cathodic liquor. The sulphuric acid can be replaced by about 20 per cent hydrochloric acid. If sulphuric acid is used, glycolic acid is obtained from the electrolytic solution by neutralizing the latter with lime under stirring until all the sulphuric acid and oxalic acid are neutralized. In order to remove the last traces of sulphate of calcium, the inventor uses barium carbonate and oxalic acid in the usual way. In case hydrochloric acid is used instead of sulphuric acid during electrolysis it is only necessary to evaporate the hydrochloric acid in order to get glycolic acid.

Electrolytic Production of Seamless Iron Receptacles.—T. A. Edison, 850,912, April 23, 1907. Application filed Oct. 5, 1903.

The object is to produce by electrolysis seamless iron cans, nickel-plated on the inside, for use as cans for the Edison alkaline battery. Three plating tanks are used. In the first, a thin copper deposit is obtained on revolving hollow brass or copper molds in the following way: The mold is covered

with a very thin layer of paraffine wax not more than 0.005 or 0.025 inch in thickness. Graphite is then applied to the surface in finely divided form so as to entirely coat the mold, the coating of wax being so thin that the graphite apparently makes contact through the same with the mold. The coated mold is now placed in a copper bath with copper anodes, and is copper-plated to a thickness of about 0.004 inch. The solution may be the ordinary copper sulphate solution. The mold is then removed and washed and introduced into a second tank containing a nickel-ammonium sulphate solution. Here the mold receives an extremely thin coating of nickel about 0.001 inch in thickness. The mold is then removed and washed and put into the third tank containing a ferrous-ammonium sulphate solution $\text{Fe}(\text{H}_2\text{N})_2(\text{SO}_4)_2$ with iron anodes. The iron solution should be absolutely neutral and free from ferric salts. It may carry from 12 to 15 per cent of the double salt. To prevent the solution from becoming acid, small quantities of ammonia or other alkalies are added at suitable intervals. The plating of iron is effected by a current of 1 to 1.2 ampere per square decimeter. The plating is continued for from 30 to 35 hours at a temperature of not below 40° C. , thereby giving a coating of about 0.020 inch in thickness. In order to prevent the formation of pits or holes in the deposited iron coating, which would be likely to form by the accumulation of gas bubbles thereon, and in order to secure a very smooth surface a quantity of crushed charcoal is introduced into the solution, whereby the added material will rub over and scour the surface of the deposited metal to polish the same and wipe off any gas bubbles which may tend to accumulate. A small percentage of carbon will in this way be incorporated with the deposited iron, which, therefore, in the subsequent annealing is converted practically into a superior product of soft steel containing almost 0.4 per cent of carbon. The particles of charcoal may vary in dimension between $1/16$ and $1/8$ of an inch, and good results are secured when the bulk of charcoal introduced is about one-half the bulk of solution. During the iron plating the mold is revolved at a speed of about 90 turns per minute. The mold is then removed from the tank and washed in water at a temperature of about 75° C. , thereby melting the wax originally deposited on the mold. The deposited can is then removed from the mold and is annealed by heating it to a red heat in a closed retort containing a non-oxidizing atmosphere, such as hydrogen gas. After annealing the articles are allowed to cool in the same atmosphere. Finally, the copper originally deposited on the graphite is removed by filling the can

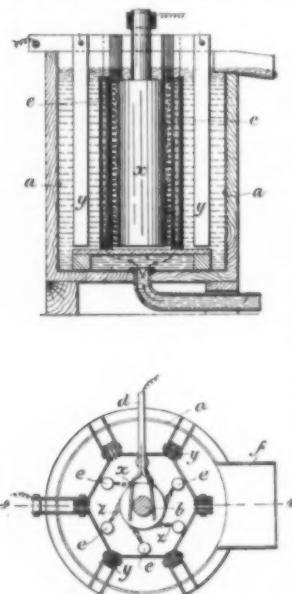


FIG. 7.—ELECTROPLATING WITH HIGH-CURRENT DENSITY.

with a solution of copper nitrate and sodium nitrate and using the can as anode against a copper cathode.

Electrolytic Deposition of Copper.—H. C. Harrison and J. Day, 858,341, June 25, 1907. Application filed Aug. 7, 1902.

Much higher current densities than are usual become practicable if the layer of electrolyte right next to the cathode surface is continually renewed. This is done by the inventors as shown in Fig. 7, when the object is to get a tough, smooth

and homogeneous deposit of copper in form of a tube, which is directly of commercial utility without having to be recast; or it may be cut so as to give a sheet; *x* is the cathode on which the deposit is to be produced. It is revolved by means of the spindle *b*, and the current is introduced through the brushes *d*. As anode a number of copper bars *y* are used placed around the cathode; *e* are series of vertical pipes spaced about equidistant from one another and disposed concentrically around the cathode *x* and parallel to its longitudinal direction. These vertical pipes *e* are provided at frequent intervals with holes or nozzles in such a position that they will direct jets *z* of electrolyte in a direction tangentially to the surface of the cathode.

Plating Apparatus.—D. F. Boderick, 858,059, June 25, 1907. Application filed Aug. 10, 1906.

In order to utilize to the fullest extent an endless carrier in an electroplating plant, two superimposed platforms are provided with a number of tanks on each of them containing the various baths which it is desired to use in the plating process. The endless carrier travels over both series of tanks, the work to be plated being suspended from the carrier. Arrangements are made to let the carrier rise and descend so as to dip the work successively in the tanks of the upper series, and then to dip them successively in the tanks of the lower series when the articles held by the carrier are traveling toward the starting point. In this way the return travel of the carrier is utilized in the plating process.

Anode for Electroplating.—A. J. Deloye, 858,160, June 25, 1907. Application filed Jan. 31, 1907.

The anode comprises "a body portion or core of gradually diminishing taper from its upper to its lower end, said core being substantially oval or elliptically-shaped in cross-section and having a series of integral outwardly-projecting obliquely disposed spurs or projections formed one above the other and on the narrow edges or sides of said body portion, said projections being of gradually decreasing length from the upper to the lower end of the anode." The object of the construction is to increase the working surface and the dissolving action of the anode.

Nickel-Silver Plating.—R. H. Marshall, 850,944, April 23, 1907. Application filed Oct. 18, 1906.

Plating with an alloy of silver and nickel has the advantage that it is cheaper than plating with pure silver, that it gives an unusual lustre and reduces the liability of corrosion or tarnishing. The electrolyte consists of a solution of $1\frac{1}{2}$ ounces of double cyanide of nickel and the same amount of double cyanide of silver, or chloride of silver, in 1 gallon of water. Pure silver anodes are used and the bath is replenished from time to time with additions of double cyanide of nickel.

Making an Abrasive Body by Electroplating.—E. G. Case, 12,507, Nov. 27, 1906. Application filed Jan. 10, 1905.

In order to provide an abrasive surface which is practically inherent in the body to which it is applied and therefore has high wearing qualities and permanency, the abrasive substance, such as carborundum, emory, etc., is powdered on the surface, while the latter is simultaneously subjected to an electroplating process. A metal coating is thereby deposited over and around the particles of the abrasive material and permanently fixes the abrasive material to the underlying body, since the abrasive particles become embedded in and fastened by the plating.

Electroplating Apparatus.—A. F. Schroeder, 866,311, Sept. 17, 1907. Application filed March 18, 1907.

Details of construction and mounting of a tumbling drum for electroplating with an axial shaft for revolving the drum.

Electrolytic Purification of Liquids.—J. T. Harris, 857,277, June 18, 1907. Application filed June 20, 1903.

An electric current is passed through the water or liquid to be purified, and the liquid is simultaneously subjected to the action of a magnetic field. The anodes are of a magnetic

metal which yields an insoluble, flocculent hydroxide, such as iron. "The magnetic field, acting upon the iron anodes and the liquid in contact with them, increases the volume of hydroxide produced by the electric current. This hydroxide combines with and coagulates the organic matter in the water, and the coagulum is subsequently removed by sedimentation or filtration, or both. The water is preferably agitated and thoroughly aerated during treatment, by injecting upward through it streams of filtered air, which may be partially ozonized. In some cases, especially when the water contains free acid, coagulation and removal of the impurities is facilitated by the introduction of a suitable reagent, before, during or after the electrolytic treatment."

Electrolytic Cell.—A. O. Tate, 857,909 and 857,910, June 25, 1907. Application filed Sept. 28, 1904.

The apparatus appears to be intended for electrolytic purification of water. The peculiar construction of the cell is indicated by the first claim of 857,909, which relates to "an electrode for an electrolytic cell embracing positive and negative conductors of relatively good conductivity, located closely adjacent to each other and mechanically and electrically separated by an insulating medium, the lateral edges or faces only of the conductors being exposed to the electrolytic solution, so as to constitute an electrolytic field therein."

Purifying Water.—A. O. Tate, 860,771, July 23, 1907. Application filed July 27, 1904.

In this patent apparatus is described, the essential feature of which is the alleged separation and disintegration of solid matter from water through the combined agency of electrolytic action and power-driven separating devices successively actuated.

Treating Liquors by Electricity.—C. H. C. Koch, 859,178, July 2, 1907. Application filed Sept. 5, 1902.

In order to age alcohol beverages or liquors he puts them in a barrel which contains two plates at both ends. These plates are used as electrodes. The 500-volt traction current is said to be particularly suitable; the treatment may last about a day or less or more.

Ameliorating and Sterilizing Liquids.—V. Dorn, 855,449, June 4, 1907. Application filed Jan. 25, 1904.

To ameliorate or age wines and spirits or to sterilize liquids the inventor uses a process "consisting in saturating the liquid with oxygen and simultaneously passing an electric spark through the liquid."

Plating Separators.—P. R. Greist, 854,943, May 28, 1907. Application filed March 13, 1907.

In plating small metallic articles a number of them are usually strung on holding wires. To have them at a proper distance from each other the inventor uses little separating devices which consist essentially of a piece of wire of a length approximately equal to the distance between the articles. The wire has at each end an eye, so that it may be strung on the holding wire between the articles. The eyes are so bent as to form only small points of contact with the articles to be plated.

BATTERIES.

Making Nickel Films or Flakes.—T. A. Edison, 865,687 and 865,688, Sept. 10, 1907. Application filed Jan. 19, 1907.

Assigned to Edison Storage Battery Co.

For making films of metallic cobalt or nickel, Mr. Edison uses a copper cylinder with a polished nickel-plated surface, which is first immersed in a suitable cobalt plating bath, such as a concentrated solution of cobalt chloride with cobalt anode, and while the cathode is rotating an exceedingly thin film of cobalt, 0.0001 inch or less in thickness, is plated on the cathode. This is then washed and placed in a solution of copper sulphate containing about 2 per cent by volume of free sulphuric acid, whereby the cobalt is caused to go into solution and the copper is deposited as cement copper in a granular but slightly adhesive form. The cathode is then placed in a

copper plating bath of copper sulphate solution with copper anodes and an electro-deposit of copper, 0.003 to 0.0035 inch thick, is obtained on the cement copper while the cathode is rotated. It is then washed and introduced into a nickel bath consisting of a concentrated solution of nickel chloride with nickel anodes. A film of nickel 0.0002 inch thick is deposited on the copper. The cathode is again washed and a second film of copper 0.0001 inch thick is deposited. Then nickel is again deposited, and so on, alternating layers of copper and nickel being deposited until a composite sheet of the required thickness is secured. This sheet is cut longitudinally of the cathode and the sheet is cut up into strips, 10 inches long and 1/16 inch wide. These filaments are placed in a basket and introduced into an ammoniacal solution of copper sulphate (80 per cent ammonium hydrate, 5 per cent copper sulphate crystals, 5 per cent ammonium chloride and 10 per cent water) and moved up and down in this bath. The copper is thereby dissolved while the nickel or cobalt is not attacked, so that the nickel is obtained in the desired film or flake form.

Storage Battery.—T. A. Edison, 850,913, April 23, 1907. Application filed Nov. 28, 1902.

The object is to provide a relief valve and a gas separator, permitting the escape of gas generated during the charge of a battery and at the same time to separate from it any solution which may become mechanically entrained with the gas. The escape of the solution is thereby prevented while the explosion of any gases by outside sources is rendered impossible. The devices consist "of a gas-vent in the can, a dash-plate and a gauze-like or perforated diaphragm arranged in the escape vent and through which the escaping gases pass." The gauze operates like the gauze of a safety lamp, while the dash-plate causes any gases which may escape from the cell to be diffused and diluted so as to burn with difficulty.

Battery Electrode.—T. A. Edison, 860,195, July 16, 1907. Application filed April 28, 1905.

The object is to reduce to a minimum the flake-like material with which the active mass in the Edison battery is mixed for the sake of increase of conductivity. For this purpose the tubular conducting pockets are longitudinal corrugated after the active material has been introduced within the same. The latter is thereby more closely packed together to increase the area and contact between the active mass particles and the conducting flakes and the conducting walls. Furthermore, the pocket is made elastic so that it may accommodate variations in bulk of the active mass and at the same time a substantially continuous elastic pressure is applied on the active mass.

Making Seamless Battery Cans.—See the abstract of a patent of Edison above, under Electrolytic Production of Seamless Iron Receptacles.

Storage Battery.—T. A. Edison, 852,424, May 7, 1907. Application filed Nov. 23, 1902. Assigned to Edison Storage Battery Co.

Mechanical details of construction of his battery.

Edison-Lalande Cell.—T. A. Edison, 858,862, July 2, 1907. Application filed Jan. 10, 1906.

In the Edison-Lalande cell, zinc and copper oxide electrodes are used in potassium hydrate. In a modification which may be used as a secondary battery, nickel hydroxide is used as depolarizer, while a plate of metallic magnesium is employed to receive the zinc deposit plated out of the alkaline zincate solution by the charging current. The present patent refers to the addition of silicate of potash to the electrolyte, whereby the solvent power or the capacity of the solution for zinc is very largely increased and may be more than doubled than when potassium hydrate alone is used. In the Edison-Lalande cell the best composition for the electrolyte is to add to a 20 per cent hydrate solution about 15 per cent of potassium silicate. In the modification in which nickel hydroxide is used the proportions of potash and of the alkaline silicate can be conveniently increased, since there is less likelihood of the

solution freezing than with a primary battery which is often used in more exposed places.

Storage Battery.—O. F. Harvey, 853,877, May 14, 1907. Application filed Aug. 11, 1905.

In order to provide for expansion and contraction of a battery plate, it is made up of blocks of active material arranged one above the other. A flexible conducting strip is wound around these plates so as to be in contact with three sides of each of these blocks; it terminates in a lug extending from the upper end of the plate. A supporting frame surrounds the blocks and the conductor, and upon the top of the blocks and primarily spaced a distance below the top of the frame a plate rests which is moved vertically by means of guides during the expansion and contraction of the active material. Elastic means (like rubber bands) are provided which do not hold the plate in close contact with the top of the active material.

Pasted Positive Electrodes.—H. Fredet, 854,940, May 28, 1907. Application filed Jan. 2, 1904.

The inventor recommends to mix the lead oxide used in making the paste with ammonium hydrosulphide. This is stated to result in dense coherent plates and to have other advantages.

Storage Battery.—W. Gardiner, 864,297, Aug. 27, 1907. Application filed Dec. 23, 1905.

Claim I reads as follows: "In a storage battery, the combination of a series of trough-like juxtaposed sections, each open at one side and having another of its sides provided with apertures contiguous to the next adjacent section; a porous strip covering said apertured side of the inner side thereof; the active material bearing against said strip within the section and a porous strip covering said open side, said sections having means interposed between them for holding the last said strip in place, and forming passages for the electrolyte between the two aforesaid strips."

Storage Battery.—L. Chronik, 861,806, July 30, 1907. Application filed Jan. 2, 1907.

Details of construction of a battery plate of the Plante type. The first claim refers to "an electrode for secondary batteries, comprising pairs of plate sections, each section comprising a bar having secured thereto spaced strips elliptical in cross-section and provided on each side with integral oblique ridges, the ridges on one side running in the opposite direction to the ridges on the other side, said strips being arranged with their widest dimensions transverse to the bar, the strips of one section being arranged between the strips of the other section."

Storage Battery.—W. Gardiner, 860,291, July 16, 1907. Application filed May 20, 1905.

The active material is placed in a plurality of independent holders, and these in turn are placed within a cage, which constitutes the body of the plate, and which may be duplicated or repeated in the battery as often as need be for creating a plate of the desired size, and between the cage and the holder, or at other point between the active material and the cage, is placed a diaphragm or sheet of porous material which will absorb the liquid of the battery and allow the same to have free access to the active material, while preventing the detached particles of the latter from finding their way into the bottom of the cell or other place where they are liable to collect and short circuit the battery."

Storage Battery.—J. Diamant, 859,753, July 9, 1907. Application filed Nov. 28, 1906.

Ordinary negative spongy lead plates lose after some time their capacity, because the porosity at the outside surface is diminished, although the inner particles of the active mass still retain their porosity. To overcome this trouble the inventor simply turns the active mass around so that the inner mass later becomes the outside surface, one or more sectional planes being provided parallel to the surface for this purpose. Claim I relates to a process for prolonging activity of spongy

lead plates for electric storage batteries, which consists in dividing the plates into sections and then varying the relative order of the sections to bring the internal surfaces to the outside and the deteriorated surface to the inside."

Storage Battery.—J. Knobloch, 865,503, Sept. 10, 1907. Application filed Dec. 26, 1906.

The plate is of the pasted type, and the active material is held firmly to the support by enclosing it in perforated hard rubber envelopes.

Primary Battery.—Charles E. Hite, 851,353, April 23, 1907. Application filed May 17, 1906.

Details of construction of a battery, consisting of a series of cells in one receptacle, in connection with a common reservoir for the electrolyte, so that the latter may be supplied to the cells when they are to be used, or may be removed when not to be used, so as to prevent local action at the electrodes.

Primary Battery.—W. P. Divine and A. J. Shinn, 859,437, July 9, 1907. Application filed Aug. 1, 1906. Assigned to Decker Electrical Manufacturing Co.

One side of the battery contains a hollow conduit connected to several rows of porous tubes, the other ends of which are inserted in a solid graphite header. Graphite rods within the porous tubes, and set in the solid graphite header, represent one set of electrodes. The hollow conduit and the porous tubes represent communicating compartments for the circulation of the electrolyte. Vertical zinc plates at both sides of the rows of porous tubes represent the other set of electrodes.

Battery.—B. B. Downs, 855,880, June 4, 1907. Application filed April 2, 1906.

The bottom of a containing box is filled to a depth of half an inch with a layer of melted wax or any other suitable insulating sealing compound. The cells are then placed on this layer and the electrical connections are made; a melted wax or other compound which melts at a lower temperature than that of the insulating material on the floor, is then poured into the box until the cells and their connecting wires are entirely submerged.

Dry Battery.—C. D. Manville, 852,188, April 30, 1907. Application filed Nov. 20, 1906.

In order to avoid the impairment of batteries used on automobiles, the battery is cushioned so as to avoid undue jar and agitation. For this purpose a coil spring is provided within the casing below the battery.

Dry Battery.—S. Cochrane, 851,402, April 23, 1907. Application filed Jan. 19, 1906.

The zinc cup is embedded in a cover of absorbent fibrous material, the outer side of which is impregnated with a waterproof and acid-proof insulating compound, such as an asphaltum compound or a petroleum compound, while the inner side is left absorbent and is impregnated with the electrolyte.

Battery Cover.—A. H. Marks, 859,091, July 2, 1907. Application filed Sept. 12, 1906.

The cover for battery cells or boxes comprises a rigid plate of hard rubber with a continuous flange of soft rubber, extending along the entire edge and depending from it so as to enclose the upper end of the box.

DISCHARGES THROUGH GASES.

Fixation of Atmospheric Nitrogen.—C. P. Steinmetz, 865,618, Sept. 10, 1907. Application filed April 20, 1907. Assigned to General Electric Co.

In order to produce nitrous compounds from atmospheric air, the air is exposed to the action of an electric arc of minimum volume and greatest practical length. For this purpose a single electric arc, maintained by a direct current, is deflected or drawn out latterly by magnetic means, like in the Birkeland-Eyde process. But contrary to the practice in the latter process, the arc is not broken but is drawn out only to a distance within which it can be safely maintained. It is simultaneously magnetically rotated within its sphere of action so

that it sweeps through the air which is converted into nitrous compounds. The rotation serves the double purpose of extending the sphere of action of the arc and of limiting the time within which the arc acts upon any portion of the air passing through the converting chamber. The rotation of the arc may be produced by a rotary magnetic field generated in the well-known manner by means of polyphase currents.

Sterilization of Water by Ozone.—M. Otto, 837,107, Nov. 27, 1906. Application filed July 1, 1904. Assigned to American Ozone Co.

Details of construction of a sterilizing apparatus using ozone. The ozone or ozonized air is drawn into the apparatus by the action of the same stream of water which is to be sterilized. The regulating and setting in motion of the stream of water and the stream of ozone are performed by hand or automatically by means of one and the same mechanical contrivance. The same regulating apparatus regulates the operation of the ozonizer, so that when sterilization stops the electric current in the ozonizer is also broken.

Ozone Generator.—J. W. Molliere, 852,133, April 30, 1907. Application filed July 18, 1906.

Details of construction of an electrotherapeutical instrument for the production of ozone and means for supplying it to patients.

MISCELLANEOUS.

Making Homogeneous Bodies of Tantalum.—M. von Pirani, 848,600, March 26, 1907. Application filed Oct. 4, 1906. Assigned to Siemens & Halske Co.

To make homogeneous bodies of tantalum, formerly tantalum powder was formed into a sufficiently solid body by pressing it together and by passing an electric current through the mass, it was fused together. This patent refers to fusing

of tantalum by cathode rays. The glass vessel *a* in Fig. 8 is tightly closed by means of metal covers *b* at two opposite ends. The copper cover serves as cathode and carries a reflector-shaped cathode-ray emitter *c*, in the focus of which the metal *d* lies which is to be melted and which is connected to the anode. The vessel *a* is exhausted of air to the extent required for cathode radiation. The metal, which is preferably powdered, melts very quickly under the action of the cathode rays. The cathode rays may easily be moved from the outside by the aid of a magnet in such a way that all parts of the material to be melted are successfully struck by the rays.

FIG. 8.—MELTING WITH CATHODE RAYS.

The method is clean and requires no mechanical device within the tube.

Ductile Tantalum.—M. von Pirani, 866,385, Sept. 17, 1907. Application filed June 23, 1906. Assigned to Siemens & Halske Co.

Tantalum hydride, or hydrogenated tantalum, is produced by passing a mixture of vapors of tantalum chloride with hydrogen through a vessel containing an incandescent filament of tantalum. Tantalum hydride forms on the glowing filament in the form of scales. If this tantalum hydride is then heated in a vacuum and the vacuum is maintained by pumping off all gases which are given off, technically-pure ductile tantalum is obtained. Since tantalum hydride is a good electric conductor, the heating may be done by passing a current through. The substance melts readily in the electric arc.

Rectifier.—O. Rothenstein, 864,695, Aug. 27, 1907. Application filed Nov. 1, 1906.

An aluminium cup, filled with a potassium phosphate solution and water-cooled from the outside, forms one electrode. Within this solution and insulated from the aluminium vessel is placed a vessel consisting of some "inert" or "passive" conductor like lead, cast iron or carbon, filled with dilute sulphuric acid. A platinum point dipping into this solution forms the other electrode.

Electrolytic Rectifier.—A. S. Hickley, 861,281 and 861,282, July 30, 1907. Applications filed Feb. 7, 1907, and April 16, 1907.

In an electrolytic rectifier, such as containing a solution of ammonium phosphate and an aluminium electrode, it is necessary to prevent undue heating of the cell. In patent 861,281 the electrodes are provided with large loops extending beyond the top of the electrolyte and exposed to the atmosphere for the purpose of diffusing heat into the atmosphere. Patent 861,282 refers to special construction of the electrodes. The first claim reads as follows: "In an electrolytic cell, the combination with a receptacle for containing an electrolyte and forming a hollow electrode, a supplemental electrode within and in electrical contact with said hollow electrode, and a hollow member connected to the hollow electrode."

Magnetic Separation.—H. H. Wait, 861,782, July 30, 1907. Application filed March 20, 1905. Assigned to International Separator Co.

A mixture of particles which are so nearly alike in magnetic permeability that they cannot be directly separated in a magnetic separator, are subjected to a preliminary treatment which changes the magnetic characteristics of one constituent without affecting the others. For instance, a mixture of molybdenite and mica cannot be completely separated in an ordinary magnetic separator, but the mica differs widely from the molybdenite in its physical characteristics, notably in that it is more porous. To separate such a mixture it is first reduced to a finely divided state, such, for instance, as would pass through a sieve of $\frac{1}{4}$ -inch mesh, and is then treated with an iron sulphate solution and heated or exposed to the atmosphere. The mica being porous in its nature, receives and retains upon its surface and in its crevices a deposit of mag-

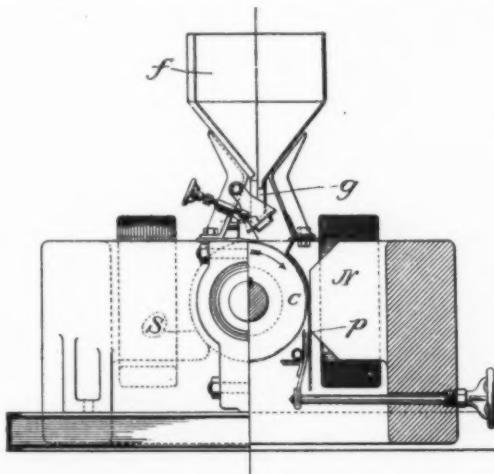
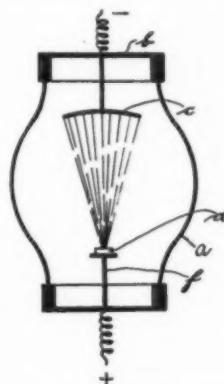


FIG. 9.—MAGNETIC SEPARATOR.

netically permeable iron oxide, so that magnetic separation from the molybdenite which is not so affected becomes possible. The magnetic separator is shown in Fig. 9, which shows a laminated armature *c*, having teeth upon its periphery and arranged to rotate between two opposing magnet poles *N* *S* of opposite polarity. The material fed into the hopper *f* on the top is carried around past one of the pole pieces. The magnetic particles are attracted to the teeth of the cylinder

and held during its rotation until they have passed beyond the path of the non-magnetic material, which falls straight down over the side of the cylinder. A divider *p* separates the two classes of materials.

Melting Through Masses.—A. E. Menne and W. Zollenhoff, 866,498, Sept. 17, 1907. Application filed Aug. 27, 1906.

It is well known that a metal plate may be cut by first heating it with the oxy-hydrogen flame and then burning the metal along the cutting line with oxygen under pressure. In the present patent the oxygen hydrogen flame is not used. The method of the inventors is a combination of electric heating with the application of an oxygen blast. It is particularly for use in melting holes in armor plate, for forming blast holes, for dismounting masses of iron and steel, for opening tap holes in blast furnaces, etc. A steel plate, for example, say armor plate, 10 inches thick, is to have a hole made through it. The one pole of a circuit supplying electric current is connected with the armor plate, and the other pole is connected with an electrically conducting pipe through which oxygen is blown. Now, if the armor plate is contacted by the pipe and if oxygen is simultaneously blown through said pipe, only a flash of the

short-circuit spark takes place, but the heat suffices for commencing the fusing and the oxygen perforates the plate in the fraction of a minute. It is here not a question of electric melting, or of a supply of oxygen to the electric arc; the action of the heating by the heat generated electrically and the melting through by means of the current of oxygen take place in point of time one after the other, as the current of oxygen indeed blows out the electric arc, or does not even allow it to form at all.

Blasting Machine.—L. W. Bowman, 848,153, March 26, 1907. Application filed April 25, 1906.

A series of connected storage batteries are housed in a closed casing. The circuit for firing the blast is closed by bringing two plugs in contact with the terminals of the battery. These two plugs are, of course, connected to the firing line. One of these plugs is inserted in a protected opening at one end of the casing, while the other plug is simply made to touch the exposed plate at the opposite end of the casing. By having the one contact point protected, the danger of accidental discharge is avoided. By using more or less cells any number of cartridges may be exploded at a single operation.

SYNOPSIS OF PERIODICAL LITERATURE.

A Summary of Articles Appearing in American and Foreign Periodicals.

IRON AND STEEL.

Properties of Cast Iron.—Max Orthey, in *Metallurgie* for 1907, Vol. IV., page 196, reports the results of an exceedingly careful test to determine the variation of properties of cast iron with its competition. He selected five kinds of pig iron of the following compositions:

Si.	Mn.	S.	C.	% of C	
				Combined	In Combination.
I	2.52	0.89	0.022	3.56	0.30 8.4
II	1.96	0.64	0.019	3.64	0.39 10.7
III	1.50	0.59	0.065	3.42	0.55 16.0
IV	1.12	0.64	0.072	3.32	0.60 18.0
V	1.08	0.72	0.154	3.26	0.99 30.3

Each of these was melted carefully in a crucible and cast into bars in well-dried sand molds, 30 c. m. long and 2, 3, 5, 10 and 15 c. m. in diameter. These bars were allowed to cool completely in the molds, then broken and sampled by planing off the whole of the fractured surfaces. The same chemical analyses were made as above, and are compared with the analysis of the pig iron used to note the effect of the casting into small or large bars, with the consequent rapid or slow setting and cooling, respectively. The comparison of the five analyses of the pig irons given above show the effect of decreasing silicon or increasing sulphur or both, on the state of combination of the carbon. Comparing each pig iron with the bars cast from it, the bar 10 c. m. in diameter showed practically the same proportion of the carbon as combined carbon as in the pig iron, the smaller bars a two to three times greater proportion of combined carbon, and the larger bar a slightly less. If we assume that the strength increases as the proportion of combined carbon increases, we are led to the conclusion that for thick-walled castings a sulphur content of 0.15 is decidedly advantageous in increasing the proportion of combined carbon.

Next, test bars were cast of a series of eight pig irons in which Mn, S and total C were kept practically constant, but silicon was decreased from 2.34 to 0.97, while sulphur simultaneously increased from 0.064 to 0.146. The percentage of the total carbon present in the combined state rose from 13.7 up to 26.4, and the mechanical tests showed a steady increase of tensile strength until Si 1.20 and S 0.116, and a steady decrease

of bending strength. A similar set of eight tests was made with silicon, phosphorus and sulphur constant, total carbon slightly increasing (3.27 to 3.62 per cent), and manganese rising from 0.35 to 1.56. These tests showed this increase of manganese to be practically without effect on the state of the carbon, but to sharply reduce the tensile strength and the bending strength after it exceeds 1 per cent. A similar set of eight tests was made, keeping Si, Mn, S and total C constant, but increasing phosphorus regularly from 0.24 to 1.43. The result showed this increase to have practically no effect upon the state of combination of the carbon, but to regularly decrease the tensile strength and the bending property.

The author concludes that if a casting is to have high tensile strength and stiffness, it should contain 20 to 25 per cent of its total carbon as combined carbon, which is attained by it containing 1 to 1.5 per cent of silicon and 0.06 to 0.15 sulphur, according to the thickness of the casting, with Mn about 0.5 and phosphorus 0.2 to 0.5. For high bending strength with low tensile strength, 1.4 to 2.0 per cent silicon, with Mn, P and S as low as possible. For high strength of both kinds choose the mean composition between those indicated.

Herr Orthey has made a careful investigation and contributed some valuable data to the metallurgy of cast iron.

Vanadium Steel.—In *Revue de Metallurgie* for August, Guillet reviews the recent papers of Pütz on these steels, and then adds his own latest observations. His conclusions are that for tempered steels, better tensile properties can be obtained with a steel of 6 per cent nickel and a given percentage of vanadium than from a steel with 2 per cent nickel and the same per cent of vanadium; it is very important to note, however, that carbon appears to damage these higher nickel steels, especially after a quick cooling. It is therefore recommended for steels to be tempered to increase the nickel as much as possible, keeping carbon low and vanadium normal. The proportions recommended are between the following limits:

	Per Cent.
Vanadium	0.1 to 0.3
Nickel	2.0 to 7.0
Carbon	0.1 to 0.3

With carbon 0.16, nickel 6.2, vanadium 0.12, a steel was

obtained which, tempered, gave 10 per cent elongation, 46 per cent contraction of area, elastic limit 140 kg. per square millimeter (209,000 pounds per square inch), and ultimate strength 154 kg. per square millimeter (220,000 pounds per square inch).

Boron Steels.—Guillet has had made, at the steel works at Imphy, France, a series of boron steels with 0.18 to 0.60 per cent carbon, and 0.2 to 1.5 per cent boron. His memoir illustrated by 17 fine photomicrographs, is contained in *Revue de Metallurgie* for August. He started with an electric furnace alloy made from iron oxide and calcium borate, made by Girod, containing C, 2.85; B, 32.10; S, 0.03; P, 0.005. Two series of steels were made, one with about 0.2 per cent carbon, the other with about 0.5 carbon. Their analyses were:

	C.	B.	Mn.	Si.	S.	P.
1.....	0.180	0.215	0.076	0.232	0.012	0.023
2.....	0.224	0.462	0.292	0.163	0.015	0.015
3.....	0.207	0.844	0.600	0.792	0.014	0.013
4.....	0.281	1.514	0.600	0.641	0.005	0.018
5.....	0.475	0.155	0.370	0.283	0.020	0.020
6.....	0.595	0.406	0.295	0.293	0.016	0.023

Steels with higher amounts of boron than the above could not be forged.

Analysis.—The boron was determined quantitatively by dissolving in concentrated sulphuric acid to which hydrogen peroxide was added. This is distilled to dryness, using a condenser, methyl alcohol is added and distilled again to dryness several times. The successive distillates are caught in dilute ammonia, ammonium chloride and magnesium chloride are added and the whole evaporated to dryness. The residue is heated to redness in a platinum dish and washed with boiling water. The residue is magnesia and magnesium borate, and is filtered out, washed, dried, calcined and weighed. The magnesia in this material is then determined as pyrophosphate, or volumetrically, and the boron oxide is then known by difference.

Transformation Points.—In °C.:

	Heating.	Cooling.
1.....	750-(830-850)	720-800
2.....	780-875	750-850
3.....	780-885	740-(905-875)
4.....	875-925	735-(800-775)
5.....	775	750
6.....	785	760

The conclusions are that boron raises the transformation temperatures, excepting that the point A₃ in cooling, passes a maximum at 0.8 per cent boron, and descends for higher percentages.

Micrography.—After annealing the first series at 900° and the second series at 850°, they showed under the microscope no anomalies, except small grains of a constituent which is black with picrate of soda, and polishes white. This may be a borocarbide of iron of variable composition, according to the content of boron and carbon in the steel. When tempered, this special constituent was reduced to traces in the low boron series, but was still present in considerable quantity in the higher boron series.

Mechanical Tests.—The annealed specimens showed increasing strength and decreasing ductility as the boron increased, similar to increasing carbon. The tempered specimens showed remarkable increase in tensile strength and elastic limit, however, with decreased ductility. With 0.8 per cent boron and 0.21 carbon the properties were:

Tensile strength, 175 kg. per m. m.² = 250,000 pounds per square inch.

Elastic limit, 130 kg. per m. m.² = 185,000 pounds per square inch.

Elongation, 4 per cent.

Reduction of area, 10.6 per cent.

These results are most surprising, considering the low carbon. Another unexpected property is that the resistance of this steel to shock (shock test) is double that of normal steel. The higher carbon boron steels were practically worthless after

tempering. All the low-carbon boron steels after tempering worked well under the cutting tools. All things considered, 0.22 carbon with 0.5 boron, as in steel No. 2, makes the best combination for industrial purposes. It is important to remember that these steels are practically useless in the normal state or forged, but possess these remarkable mechanical properties only in the tempered condition.

Cupola Practice.—In *Stahl und Eisen* for March 6, C. H. Jaeger of Leipzig, writes upon the construction and running of cupolas. He puts it down to start with that 4 to 6 meters is the minimum height which should exist from the tuyeres to the top; an ordinary cupola of 70 to 90 centimeters inside diameter should not have less than 5 meters. This assures good regeneration of heat by the descending material, no flame issuing from the top, and economy of fuel. In German practice, the following outputs are obtained per hour:

Inside diameter.	Quantity.
500 mm.	1,000 to 1,500 kg.
600 "	2,000 " 3,000 "
700 "	3,000 " 4,000 "
800 "	4,000 " 5,500 "
900 "	5,000 " 8,000 "
1,000 "	6,000 " 10,000 "

With a cupola of proper height, the coke consumed will be 6 to 7 per cent of the weight of iron melted; it is possible with 7 per cent to get a finely fluid machinery iron. The air should be furnished positively by a rotary blower which can furnish the required amount at pressures up to 1,000 mm. of water gage. The quantity of air required per minute for every 1,000 kg. of iron melted per hour is:

Consumption of coke 7% 8% 9% 10%
Cubic meters of air per minute 11.8 13.8 14.9 16.4

The charges to the cupola should be broken small and the shaft kept always full. The diameter of the tuyere nozzles must be small enough to give the blast sufficient velocity to properly penetrate the charge; 30 meters per second is sufficient for small furnaces, and 50 meters for large ones. Assuming a certain velocity per second and a certain quantity of air to be blown in per second, the quotient will be the total nozzle area. The number of nozzles is then assumed; more will be needed for a large than for a small cupola, and the area of each nozzle is thus found, from which its diameter is calculated.

COPPER.

Electrolytic Production of Copper.—An article in the *Oesterreichische Zeitschrift für Bahnen und Hütte*, and abstracted in London *Electrician*, Sept. 6, gives an account of the methods employed at Medzianka for producing copper by electrolytic means. The produce of the mine is divided into rich ore, with 50 per cent of copper, which is separated underground and mixed ore with 16 to 20 per cent containing calcite and limestone. The ore is crushed, mixed with 5 per cent of damp brick earth and moulded into blocks, which are subjected to a partial roasting, with a free access of air, converting the copper into sulphate and oxide. The roasted ore is crushed fine and lixiviated in lead-lined tanks, with the spent liquor of the electrolytic baths containing about 5 per cent of free sulphuric acid. A liquor containing about 5 per cent of copper and 1 per cent of free sulphuric acid is obtained. After passage through a filter press, this is electrolyzed in vats of about 35 cubic feet capacity. Insoluble anodes of lead plates in cloth bags and thin copper cathodes are used. A current of 1,000 amperes at 2.5 volts, corresponding to a current density of about 1 ampere per square decimeter of cathode surface, is used, producing metallic copper, free sulphuric acid and oxygen. The deposited copper, about 1.1 gram per ampere-hour, is nearly equal to the theoretical amount. The energy consumed per kilogram of copper is 2.28 kw-hours or 3½ hp-hours. The liquor is exhausted in

about 35 hours, when it is returned to the extraction vats for the treatment of fresh ore. The cathodes remain in the bath for about a month, when the deposit (1 in. to $1\frac{1}{4}$ ins. thick) is removed.

GOLD AND SILVER.

Tube Mills at Guanajuato.—Mr. C. Van Law, in the *Mining and Scientific Press*, Aug. 17, gives some data about the Abbé mills running at Guanajuato, for the last eight or nine months. The mills are 4 feet 6 inches x 20 feet; they handle about 80 tons of pulp per day of the following grade: + 40, 11.2 per cent; + 50, 11.2 per cent; + 60, 8.9 per cent; + 80, 16.6 per cent; + 100, 16.3 per cent; + 120, 26.1 per cent; — 120, 9.7 per cent. The moisture is 60 per cent. The grade of the discharged pulp is as follows: + 40, 0.5 per cent; + 50, 1.7 per cent; + 60, 2.9 per cent; + 80, 6 per cent; + 100, 16.2 per cent; + 120, 21.8 per cent; — 120, 51.2 per cent. The mills are kept filled with pebbles slightly above the center, and the wear of pebbles is approximately $\frac{1}{4}$ pound per ton of ore treated. The life of the silex linings was eight months. The power required by the mill is 60 hp. at the start, which drops immediately to 43 hp. as soon as the mill is at running speed. The operation of the mills has been attended by no difficulty whatsoever, and the mills have given no trouble mechanically since their installation. Mr. Van Law calls attention to the fact that the truth of the supporting tires and the homogeneity of the material of which they are composed, is of great importance, because if the slightest irregularity occurs either as an original defect or during the operation of the mill, bumping of the mill would ensue and cause the destruction of the mill and perhaps its foundation. It was found at Guanajuato, on starting the first mill, that a film of $\frac{1}{16}$ inch of sand had accumulated at certain oily spots on the circumference of the tire, and this causes violent bumping, so that the mill had to be stopped and the ring tire carefully cleaned off. These tires are kept at all times carefully cleaned, and a little oil is put on the surface of the tires once or twice a day. As a result, there has not been the faintest bump or vibration about the mills and they run as quietly and smoothly as possible. In order to limit the end motion in the Abbé mill, two guide rollers with vertical axis bear upon the sides of the supporting tire next to the gear end, and earlier users of the mill had trouble with those rollers being worn out quickly by the tendency of the mill to run endwise. At the suggestion of the Abbé Co. experiments were made to cant the friction rollers upon which the tire moves, and it was found that by this adjustment the main tube could be made to float entirely free on its supporting rollers without touching either of the guide rollers at all. The mill ran for three months without touching either guide roller, and normally it hardly touches them once a day.

Ancient Gold Mining in Egypt.—In the course of an interesting article under this title in *Mining and Scientific Press*, Aug. 17, Mr. C. Herzig gives the following screen analysis of an ancient tailing: Retained on 100-mesh, 1.85 per cent; pass 100 and retained on 160-mesh, 4.4 per cent; pass 160 and retained on 200-mesh, 5.75 per cent; pass 200-mesh, 88.00. This shows that the ancients already practiced what we now designate under the name of sliming, and Mr. Herzig estimates that with oxidized gold ores they must have recovered practically all the gold, with the exception of, perhaps, the very lightest particles. The ore was ground by staves between stones, usually of granite, and the gold was caught on crude tables built of rock, 8 to 10 feet long and about 3 feet wide, which sloped sufficiently to let the water run off freely.

A Cheap Form of Cyanide Plant.—For many small mills the tailings are too high in value to be thrown away, but their owners are averse or unable to spend money for the erection of a permanent cyanide plant. In a paper to be read at the October meeting of the British Institution of Mining and Metallurgy, Mr. C. Hunter gives the specifications for a cheap

and portable cyanide plant to fit such cases. He states that this form of plant is largely in use in Southern Rhodesia, and that such plants give good results, last well and are simple and convenient in operation. The contract calls for the complete equipment of a cyanide plant, including all materials and labor, the plant to be delivered free at the nearest railway siding. The plan is to consist of the following: 1. Five leaching vats, 10 feet diameter x 4 feet 2 inches deep. 2. Two solution tanks, 8 feet diameter x 6 feet deep. 3. Two extractor boxes, seven compartments each, the compartments to be $15 \times 15 \times 15$ inches, with 3-inch baffle board partitions. 4. A steam pump, Knowles duplex type with $1\frac{1}{2}$ -inch delivery and 2-inch suction. 5. All necessary pipes, valves, fittings and hose necessary for the complete equipment from and to the tailing and solution tanks and extractor boxes, water connections and steam connections, including stop valves. 6. All necessary gratings, matting, jute, cloth, manila rope and packing. 7. Distributor tray for raising pipes and hose connections from the leaching vats, with partition and two outlets to the slimes catchers. 8. Two slimes catchers, each $16 \times 16 \times 16$ inches, with baffle board. The leaching and solution tanks are to be constructed of 22 B. W. G. galvanized corrugated iron, stiffened at the top with $1 \times 1 \times \frac{1}{4}$ -inch angle-iron, and riveted and soldered inside and outside. The extractor boxes are also to be constructed of 22 B. W. G. iron. All solution pipe is to be $1\frac{1}{4}$ inches, leaching pipe 1 inch, return to solution tank from pump $1\frac{1}{2}$ inches, return from boxes to solution tank $1\frac{1}{2}$ inches; the pipe lines are to be installed complete with all necessary fittings. The gratings for the solution tanks are to be constructed of 1×1 -inch strips, on $3 \times 1\frac{1}{2}$ -inch bearers, with perfect sweep sides built in two sections, covered with cocoa matting and jute cloth turned over at the edge and calked with manila rope. The distributing tray and the slime catchers are also to be made of 22 B. W. G. galvanized iron. All galvanized iron work must have at least one coat of Stockholm tar, applied hot. The whole plant is to be supplied, erected and handed over in running order for £300, divided about as follows: Five leaching tanks at 20 = £100; 2 solution tanks at 15 = £30; 2 extractor boxes at £12.10s. = £25; matting and rope, £13; 5 gratings at 7 = £35; piping, £40; cyanide pump, £26.10s.; excavations, foundations, erection, railway fares and carriage, £30.10s.; a total of £300. The author states that the first of these plants was erected March, 1905, has been running constantly and shows no signs of wear. It has paid for itself out of the first two months' profit, and other plants have done the same.

Recent Improvements in Tube Mill Practice.—A source of considerable expense in tube milling has been the use of imported pebbles for grinding. Attempts have been made with more or less success to substitute quartz pieces from the quartzy ores, but up to now pebbles were considered a necessity and were even shipped to remote localities at high cost. An interesting paper on the substitution of pieces of Rand banket quartz in the tube mill has been communicated to the Chemical, Metallurgical and Mining Society by Mr. K. L. Graham, and is published in the *Journal* of the Society for April. The author has carried out comparative experiments by using two tube mills of the same dimensions, one filled with pebbles and the other with pieces of quartz. The tube mills were both 22 feet long x 5 feet 6 inches diameter, and lined with silex blocks, 6 inches x 6 inches x 4 inches, laid on edge; the joints were staggered so as to prevent wear of the lining in circumferential corrugations. Mill No. 1 was an Allis-Chalmers, and mill No. 2, Fraser & Chalmers type, No. 1 being loaded with quartz and No. 2 with Danish pebbles. All other conditions were kept as nearly as possible the same, including revolutions per minute, weight of solids fed 24 hours and percentage of water to solids. The mills ran together for eighty-one days, after which mill No. 2 had to be stopped on account of mechanical defects. The efficiency of the grinding done by the mills was ascertained by the increase in the amount

of material passing through a 90-mesh sieve, between the inlets and the outlets of the tube mills. The following table shows the results for the month of January of this year, and it is apparent that the No. 1 mill, loaded with quartz, gave the highest efficiency. This mill maintained during the entire run of eighty-one days:

NO. 1 MILL—QUARTZ FED 171.5 TONS.

Grade.	Entering Tube Mill.	Leaving Tube Mill.
On 60-mesh.....	68.68	9.73
On 90-mesh.....	19.57	26.28
Through 90-mesh.....	11.75	63.99

NO. 2 MILL—PEBBLES FED 10 TONS.

Grade.	Entering Tube Mill.	Leaving Tube Mill.
On 60-mesh.....	68.68	11.32
On 90-mesh.....	19.57	27.24
Through 90-mesh.....	11.75	61.44

As No. 2 mill had to be stopped at the end of eighty-one days, the question of wear and tear of linings could not be carried to a full conclusion. However, No. 1 mill was kept running and the lining lasted for 140 days, while a similar lining where pebbles had been used gave only a life of 124 days, and was thus shown that the basket quartz pieces were not any more severe on the lining than the round pebbles. The saving in cost obtained by using the basket quartz was considerable, as the 10 tons of pebbles used cost £60, while the 171.5 tons of pieces of basket quartz were sorted, trammed and fed at a cost of approximately 2s. per ton, or a total of £17, thus showing a saving of £43 per tube mill per month. In order to account for the higher results obtained from the mill which was loaded with irregular pieces of quartz, the author gives it as his opinion that a higher percentage of the work done in the tube mill is by impact rather than by grinding, the quartz lumps, on account of their irregular shapes, being lifted higher in the mill, with less sliding amongst themselves and on the lining than in the case with the smooth, round pebbles. When quartz pieces are fed into the mill, some automatic contrivance is necessary for catching the particles which are discharged through the holes in the outlet plate of the tube mill. These particles may amount to about a quarter of a ton per mill per day, and if allowed to go to the shaking baths they will choke up the distributing launders, detach amalgam from the plates and cause endless trouble. The device used by the author is a perforated trommel, which is fixed to and revolves with the tube mill. Buckets are attached to the inside of the periphery which elevate the quartz particles and discharge them into a chute, which carries them by means of a pipe through the bottom of the launder to a convenient receptacle. The author also mentions that by the use of high-priced quick-setting cement he has succeeded in relining a Davidson mill, 20 x 5 feet, in two days and three hours, this being the time elapsed between the stopping and restarting of the mill. In regard to peripheral or central discharge, he remarks that contrary to prediction in the "early days" of tube milling, the majority of mills built for peripheral discharge have been converted to central discharge with beneficial results.

NICKEL.

Nickel-Tin Alloys.—Guillet publishes in *Revue de Metallurgie* for June a long article on the microscopic and thermophysical properties of these alloys, which he has studied throughout their whole extent, and finds different results from those previously reported. Twenty alloys were made and completely studied, from 15 per cent tin up to 95 per cent, all being analyzed chemically to fix definitely their composition. The nickel used contained 1.5 per cent of cobalt and 0.3 to 0.4 per cent iron.

With 0.1 per cent of nickel the melting point falls from that of tin, 233°, with the pyrometer used, to 230°; from this

eutectic the curve of melting points rises steeply to 645° with 5 per cent nickel and 790° with 10 per cent; then more slowly to 1,021° with 20 per cent, and to a maximum of 1,254°, with 43.55 per cent of nickel. Guillet remarks that this does not correspond to an atomic formula, and is only a solid solution. Thus another of our illusions—that a maximum on the melting point curve corresponds to a chemical formula—is shattered; and we must get to some broader generalization. Above 43.5 per cent nickel the curve slopes downwards gently to a eutectic at 64 per cent nickel, and then rises gradually to the melting point of nickel, 1,465°. Guillet summarizes his work by cataloging the following eight constituents of nickel-tin alloys:

Tin.

Combination NiSn.

A solid solution containing 37.5 to 47.5 per cent nickel.

A solid solution containing 57.5 to 62.5 per cent nickel.

An allotropic modification of the latter.

A second modification of the latter.

A non-magnetic solid solution of nickel.

A magnetic solid solution of nickel, from 95 to 100 per cent nickel.

Nickel-Lead Alloys.—A. Partevin gives us the first study of this binary system, in *Revue de Metallurgie* for August. Alloys were made with 0.6, 1.5, 10 per cent nickel, and every other 10 per cent up to pure nickel. The melting points of lead and nickel were 327° and 1,484°. The conclusions are that, starting with pure lead the melting point is lowered to eutectic at 323° by 0.07 per cent of nickel; from 0.07 to 7 per cent of nickel the liquid is homogeneous, but at temperatures between 323° and 1,365° crystals of nickel separate out and leave the eutectic. From 7 to 60 per cent nickel the alloys are entirely liquid above 1,365°, but at 1,365° crystals of nickel separate out of the eutectic, and at 323° the eutectic sets. From 60 up to 100 per cent nickel, that metal separates out at temperatures varying from 1,365° to 1,484°, leaving the alloy with 7 per cent nickel, which finally solidifies as above dissolved. The net conclusion is that nickel and lead form no combination, and that while entirely non-miscible in the solid state they are only partially miscible in the liquid state.

Nickel-Arsenic Alloys.—K. Friedrich and F. Bennigson give us in *Metallurgie* IV. (1907), pages 200-216, a fine study of these alloys, accompanied by thirty magnificent photomicrographs. Experts in blow-pipe analysis will recall Plattner's classical process for determining nickel quantitatively by weighing it as Ni³As, and will appreciate the bearing of these results upon the Plattner test. The alloys were made in an electric furnace, the highest reached being 56.5 per cent of arsenic. As far as investigated, the melting point of nickel is reduced nearly linearly by arsenic from 1,484° 900° at 27.8 per cent. From this eutectic it rises to a maximum of 998° at Ni³As², 33.5 per cent of arsenic. Then it falls to a second eutectic at 43.3 per cent arsenic, melting at 804° C. Then occurs a second rise to the compound NiAs, with 55.7 per cent arsenic, melting at 968°. Ni³As² may occur in some of the mixtures during cooling. Only alloys with less than 29 per cent of arsenic are attracted by the magnet.

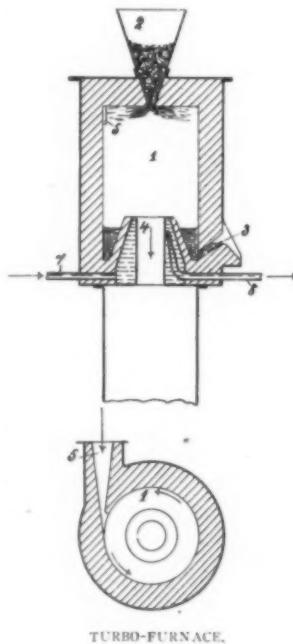
Peak Load in Electricity Works.—In the London *Electrician* of Aug. 16 and 23 the use of the surplus power of electric stations at hours of light load for electrochemical purposes is advocated. It is stated that the British Carbide Factories, Ltd., intend to erect a calcium carbide factory close to the Yorkshire Electric Power Co.'s generating station at Thornhill. "The arrangement which, it is stated, has been arrived at between the two companies provides that only the surplus power of the Power Co. is to be utilized, so that the energy employed for electrochemical purposes will fluctuate according to the load on the power station." It will be interesting to learn how this arrangement will work out.

RECENT METALLURGICAL PATENTS

IRON AND STEEL.

Turbine Furnace.—We recently noticed that Dr. C. G. P. de Laval, of steam turbine and cream separator fame, is applying the rapid-rotation principle to his electric zinc furnace. He now applies the same principle to iron reduction (861,593, July 30, 1907). A pulverous charge of iron ore, carbon, etc., is introduced continually and uniformly in or near the center of the furnace chamber, and is brought into a rapid rotation by means of a gas or air current which, by pressure or suction, is introduced tangentially at the circumference of the furnace chamber and thus is brought into rotation. The gas or air current is thereby intimately mixed with the charge, which, owing to the influence of the centrifugal force, moves towards the circumference of the furnace chamber from its central inlet, whereas the gas or air current moves in spiral course from its circumferential inlet to its central outlet at the other end of the furnace. The charge and the gas or air current thus move in opposite directions. In Fig. 1, which shows vertical and horizontal cross-section, the furnace chamber 1 is supplied with the pulverous ore charge through the hopper 2. The air or gas is introduced into the furnace through the pipe 5 with great velocity by pressure or suction. The gas current is preferably carbon monoxide or a mixture of air with carbon in a proportion to form carbon monoxide within the furnace. The outlet for the gases is at 4, while the reduced iron is drawn off through 3. The walls of the gas exit 4 are water-cooled, since this diminishes the tendency of dust carried along with the gases to adhere to the walls.

Open-Hearth Process.—In our last issue, page 344, we gave a review of the new steel process of Mr. Horace W. Lash. In this connection a recent patent of Mr. Lash (864,972, Sept. 2) is interesting. While the general principle is the same as stated in our former article, the object of the present patent is to make finely-comminated oxide of iron (magnetic concentrates, iron sands, etc.) available for steel refining, especially in the acid or basic open-hearth process. As described before, the magnetic concentrates are mixed with pig or cast iron (containing a high percentage of metalloids) and carbon and the mixture is finely ground. About 50 to 75 parts of ore are mixed with 50 to 25 parts of pig iron, while the carbonaceous material runs from about one-sixth to one-tenth of the weight of ore. After adding sawdust and a temporary binder, such as molasses, silicate of soda or pitch, the mixture is pressed into the form of briquets, which are heated to a temperature below the fusing point of the mass, but above the fusing point of the cast or pig iron. The sawdust is oxidized and disappears, leaving the briquet porous. A portion of the oxide is reduced by the metalloids in the cast iron, which fuses and coats the particles of oxide, with the result that the particles of new iron stick together and the briquet becomes an adherent mass of great consistency and strength. A certain propor-



tion of the carbonaceous material disappears and the rest of it remains in the briquet. The briquets are added to the open-hearth furnace either by being charged upon the hearth or being added to the bath. When the briquets are to serve as a substitute for part or all of the scrap commonly used in open-hearth practice, the proportion of carbon used is somewhat lowered, so that the briquets shall, upon being fused in the hearth, add thereto a quality of metal substantially equivalent to scrap.

Open-Hearth Process.—Henri Delporte, Fils (861,440, July 30, 1907) proposes to conduct the open-hearth process in two or more stages for facilitating the refining. The furnace first receives the ore and limestone or lime and is then charged with pig iron and scrap or with pig iron alone. During the process more refining materials are added if necessary. When the greater part of the impurities, particularly silicon, phosphorus and sulphur, have been removed, the partly-refined metal is withdrawn by being tapped into a ladle and the slags are run out of the furnace. Then the furnace is again charged with ore and limestone or lime and the liquid metal in the ladle is poured back into the furnace. In this second stage of the process, metal already higher refined, comes in contact with fresh refining material in a furnace free from slag, and the action of such material is rapid and thorough. "The impurities and particularly phosphorus are in this manner easily removed."

Pig Iron Production.—The local conditions of California, as characterized by abundance of oil and scarcity of coal, are reflected by a patent of S. McDonald (859,572, July 9, 1907). The iron oxide ore is first fused in a smelting furnace by means of oil or gas burners. The molten product is then carried to the top of a furnace, some 40 feet high, and filled with coke or solid carbon, which had been previously brought to incandescence (2,700° to 3,000° F.) by means of a temporary fire-blast. The molten ore in passing downwards through the pieces of incandescent coke or carbon is deoxidized. Besides the saving in coke, it is said to be an advantage of the process that by using a fire from fluid fuel for the preliminary fusing of the ore the introduction of sulphur into the product is largely avoided.

Welding Compounds.—A. J. Hanlon (865,887, Sept. 10, 1907) describes the following composition of a flux for welding cast iron and steel together or to other metals, such as silver, copper, etc. Six ounces of borax, 3 carbonate of soda, 3 glass, 3 oxide of iron and 1 ounce of rosin are pulverized and mixed dry. The metals to be welded are cleaned and heated, and the compound is sprinkled on them in the shape of powder while heating.

AGGLOMERATING FINES.

Use of Silica and Lime.—W. Schumacher (864,804, Sept. 3, 1907) agglomerates ore fines, blast-furnace dust, etc., as follows: Silicious materials, such as sand, quartz or flint, are ground to an impalpable powder, the particles of which have the form of flakes, needles, etc., as distinguished from the approximately prismatic or globular shape which very fine sand has in nature. This impalpable silica powder is mixed with an approximately equal quantity of lime, and is added in the amount of about 5 per cent to the material to be agglomerated. The mass is formed into briquets, which are hardened by exposing them to the action of steam under pressure in a closed vessel. Calcium silicate is thereby formed which acts as a binder. Only a very small proportion of the silicious material (only from $\frac{1}{8}$ per cent to $\frac{1}{4}$ per cent of the final product) remains uncombined.

GOLD.

Cyanide Process.—In the treatment of gold and silver-bearing ore in which a large percentage of copper is present, some difficulty is found in the recovery of the precious metals, particularly of the silver, owing to the fact that the cyanide solu-

tion becomes heavily charged with copper. It takes up 40 per cent of its own weight in copper, and when the solution is once loaded with copper, no silver values can be obtained. I. Anderson (861,628, July 30, 1907) proposes the following treatment in successive steps: Pulp containing precious metals and copper is first treated with potassium cyanide. The extracted metals are precipitated with sulphuric acid. The sulphuric acid is then neutralized with lime, whereby the cyanide solution is regenerated. The pulp is then again subjected to treatment with the regenerated solution, whereby the rest of the precious metal values is taken out. This solution now containing gold and silver is then used for the treatment of fresh pulp to take out the copper and so on as before.

Treatment of Refractory Ores.—According to a process of W. P. Wynne and J. H. Grant (862,229, Aug. 6, 1907) antimony-gold ores, pyrites and other refractory ores are powdered, and when in the form of a spray are subjected to the action of flat sheets of flame emitted from oil or gas burners which produce a temperature of 450° F. The antimony is thereby volatilized and driven off with other fumes and collected in the form of oxide of antimony in a surface condenser. The special feature of the process, however, is that the ore after passing through the flames is suddenly cooled, so that it does not sinter or fuse into a mass or clinkers, in which condition it would be unsuitable for further treatment and the extraction of gold would become impossible. For this purpose the hearths are hollow and are continuously supplied with a cooling fluid, so that the particles of ore falling on them are instantaneously cooled below the fusing point as they accumulate. They are then gradually moved forward by the rabbles from one hearth to the next.

Testing Ores in the Field.—L. M. Pritchard (861,535, July 30, 1907) proposes the following method of testing ores for gold, suitable for the use of prospectors in the field. It consists essentially in pulverizing the ore, treating it with iodine dissolved in an aqueous solution of potassium iodide to dissolve the gold, agitating the solution thus formed with mercury to form an amalgam with the gold, and separating the gold from the mercury, preferably by means of nitric acid. "Iodine mixed with potassium iodide can be easily carried by the prospector as a part of his outfit as dry salts, to which he can add water to make the solvent solution when he desires to use it."

SLIME AND PULP TREATMENT.

Washing Process.—T. Griswold, Jr. (863,061, 863,062 and 863,168, Aug. 13, 1907) patents a process and apparatus for treating slimes or pulps, for which separation by settlement and decantation would be very slow and which are not adapted to filtration or leaching. The solvent or washing fluid is passed in one direction through a series of settling and mixing chambers, while the pulp or sludge is simultaneously passed through the same series in the opposite direction. The sludge is thereby repeatedly washed, settled and rewashed in solvent of progressively increasing solvent power, and carrying a decreasing burden of "values," until when discharged at the end of the series the sludge is practically deprived of soluble values.

COPPER.

Pyritic Smelting.—R. Baggaley (862,378, Aug. 6, 1907) patents the following process for treating copper sulphide, oxide or carbonate ore. The first step is a smelting operation, by which without carbonaceous fuel or with very little carbonaceous fuel and without previous calcining and water-concentration, the ore is reduced to a matte containing about 40 per cent of copper. Into a converter, provided both with smelting twyers and bessemerizing twyers, a predetermined charge of sulphide ores is introduced, together with oxide and carbonates if desired, and with suitable fluxes, only about as much fuel being added as is necessary to ignite and thoroughly start the process. The charge is so selected and pro-

portioned with relation to its contact of iron and sulphur as to convert the bases into silicates without the use of carbonaceous fuel. In this converter the ore is smelted by the smelting twyers, and the matte, which sinks to the bottom after smelting, is enriched by the converting twyers to a point where the resulting slag will not contain a greater proportion of copper and valuable metals. The matte should contain about 40 per cent of copper.

The second step of the process is the utilization of the molten slag for the development of heat in steam boilers, etc., and is then discharged at the dump-pile. The third step consists in transferring the matte from the first step in molten state to a second converter, where it is enriched until practically all the bases to be separated are removed. The slag resulting from this operation and containing a considerable quantity of copper is returned in the fourth step to the ore bins.

The matte from the third step contains about 80 per cent of copper. It is treated again in the fifth step in a converter provided with converting twyers and with a flue for the introduction of flame, which prevents the bath from chilling at the latter part of the blow. By the action of the blast the matte is enriched to the point at which practically all the sulphur, bismuth, antimony, selenium, tellurium, etc., are eliminated. For this purpose it is necessary to blow the charge to the point where a small amount of oxide or sub-oxide of copper is formed. At the end of the blow the floating impurities are skimmed off from the surface. In the sixth and last step of the process the converter is tilted and the molten copper is poured into another furnace, the flame in which is capable of regulation, where it is poled to remove the sub-oxide, or if desired, hydrocarbon gases may be injected below the surface of the copper, and suitable additions may be made to the metal.

Two other patents of the same inventor (864,719, Aug. 27, and 865,671, Sept. 10, 1907) refer to details of construction of the converters used in his process.

NICKEL.

Mond Process.—The well-known Mond nickel process consists in heating oxide of nickel, or material containing the oxide, in a reducing gas at a temperature between 350° and 500° C., allowing the material to cool and subjecting it to the action of a stream of carbonic oxide gas whereby the nickel is volatilized in the form of nickel carbonyl. Carl Langer (865,969, Sept. 10, 1907) calls attention to the fact that it is essential to keep the temperature of the material between 40° and 50° C. at atmospheric pressure for the action of the carbonic oxide gas on nickel. Since this reaction evolves heat, artificial cooling must be resorted to, and an apparatus for this purpose is described in which the cooling fluid is passed through passages in the reaction apparatus, around or over which passages the material under treatment is moved.

TUNGSTEN.

Chloridizing Process.—R. McKnight (862,987, Aug. 3, 1907) treats tungsten ore as follows: The ore is reduced to a fine consistency, about 30-mesh, and mixed with double the amount of common salt and brought into a heating furnace, its temperature being not over 700° C. By this treatment the tungsten in the ore is converted into a volatile and soluble chloride or double chloride of sodium and tungsten, according to the equation:



The volatilized double chloride is condensed in a suitable condenser, while the residue, white-hot from the furnace, is allowed to drop into water. It quickly disintegrates and crumbles, and that portion of the tungsten which has not volatilized passes into solution, from which its acid or the metal itself can be obtained in any suitable manner. It is

stated that vanadium, uranium, molybdenum and tellurium ores can be treated by analogous methods. In some cases the inventor prefers to precipitate the acid of the rare metal by rendering its solution acid by means of hydrochloride acid. If the latter is led into the solution in gaseous form, the sodium chloride is thrown down along with the acid of the rare metal. By washing the mixed chlorides with water, the sodium chloride is obtained in the filtrate and the rare metal acid as the residue on the filter. In cases where the ore contains a metal whose oxide is soluble in ammonia, such as silver, copper, nickel, zinc, etc., the inventor uses as the condensing liquid for the volatilized portion and as the solvent for the residual portion a solution containing ammonia.

ALUMINIUM.

Alloy.—F. W. Fletcher (867,194, Sept. 24, 1907) patents an alloy for shoes of beasts of burden, consisting of 30 pounds aluminium, 1 pound gunmetal and $\frac{1}{4}$ pound white metal. The gunmetal is formed of 90 parts of copper and 10 parts of tin, while the white metal consists of a mixture of 6 parts of tin with 1 part of copper admixed with a mixture of 6 parts tin and 1 part of antimony.

METAL CUTTING WITH A BURNER.

Cutting Metal Articles.—With respect to the method of cutting metal plates, etc., with the blow-pipe, as described in the article of Mr. M. U. Schoop (page 308 of our August issue), two recent patents are interesting. One granted to Messrs. F. Jottrand and P. Sluys (859,664, July 9, 1907) is assigned to the Société Anonyme L'Oxydrique Internationale, which company had an interesting exhibit of such apparatus at the exhibition in Liège two years ago. The principle is to heat with the oxy-hydrogen flame the plate to be cut along the line of section and simultaneously direct upon this line of section a jet of oxygen under pressure. The metal is raised to such a temperature that oxidation along the line of section takes place rapidly; the metal itself does not melt, but the oxides which have a lower melting point flow readily, and the cutting line as sharp and clean as if the metal had been sawed. The present patent relates to the cutting of circular curves of any desired radius, and for this purpose the blow-pipe with the accessory oxygen tube is made one leg of compasses, so that by drawing a circle the plate is cut. A second patent granted to F. Jottrand (866,866, Sept. 24, 1907) relates to the principle of the method. The first claim reads as follows: "In an article for cutting metallic articles, means for heating the article to be cut and means for simultaneously supplying oxygen under pressure to the heated portion of the article."

Industrial Liquid Air.

Atmospheric air is a mixture of about 23 per cent by weight of oxygen and 77 per cent by weight of nitrogen. To make the constituents of air available for industrial use two ways are open. One is to combine the nitrogen and the oxygen so as to form nitrogen oxide which can be worked up into nitric acid or nitrates. The second way is to separate the nitrogen from the oxygen in the air and make both constituent gases individually available for various applications. Both methods require extreme temperatures, the first method an extremely high temperature, such as is obtainable from the electric arc; the second an extremely low temperature, since the separation of air into its constituents depends on the liquefaction of the air and its subsequent fractional evaporation.

An extensive plant for producing oxygen from liquid air on an industrial scale is now being erected in Buffalo by the Linde Air Products Co., Dr. Linde's system of air liquefaction and subsequent rectification being applied. For the annexed illustration of the plant and the information given in the following notes, we are obliged to Mr. Cecil Lightfoot,

the consulting engineer and general manager of the company.

The action of the Linde apparatus for producing liquid air is based on the refrigerating effect resulting from an expansion of air from a higher to a lower pressure and which is due to the performance of internal work. The action of any desired number of expansions is accumulated and intensified by causing each preceding expansion to act as a fore-cooler for the air for the following expansion. Since the refrigerat-

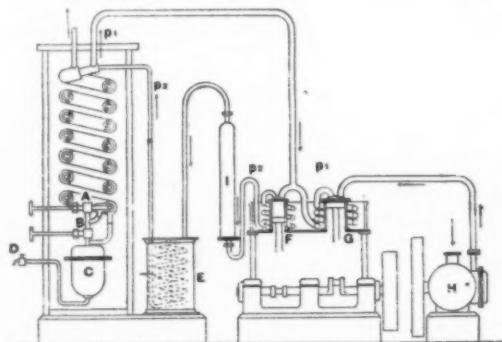


FIG. 1.—APPARATUS FOR MAKING LIQUID AIR.

ing action depends upon the difference of pressure before and after expansion, while the work of compression corresponds to the ratio of these pressures, it is advantageous to select a large difference in pressures but a small ratio of pressures. In the Linde apparatus air is expanded from an initial pressure of about 200 atmospheres to about 50 or 20 atmospheres, so that the difference of the pressures varies between 150 and 180 and the ratio is between 4 and 10.

As will be seen in Fig. 1 a triple coil is provided, which is composed of copper tubes placed one within the other. This is called the heat interchanger. Air compressed to 200 atmospheres flows downward through the innermost coil, at the lower extremity of which it is allowed to expand to an intermediate pressure of 20 to 50 atmospheres. The expanded air is then returned through the annular space between the innermost and middle coils to the top, when it is again compressed up to 200 atmospheres pressure and the cycle is repeated. Immediately behind the first regulating valve A is placed a second valve B, through which, when the operation of the machine has been brought to a state of equilibrium, a small quantity of air is allowed to escape at atmospheric pressure, a corresponding amount being introduced into the cycle from the surrounding atmosphere. Part of this air leaves the second regulating valve in the liquid state and collects in the vessel C; the remaining portion is returned to the atmosphere through the annular space between the middle and outer coils. The liquid air is drawn from the collector by means of the small cock D.

In the larger installations the necessary compression of the air is effected by means of a high-pressure air pump, which is usually arranged for two-stage compression, working in conjunction with a single-cylinder low-pressure air pump. The high-pressure cylinder F of the former draws the partly expanded air from the heat interchanger at an intermediate pressure of about 50 atmospheres, and compressing it up to 200 atmospheres pressure, delivers it to the interchanger again through the cooler E. The air which is to be added to the

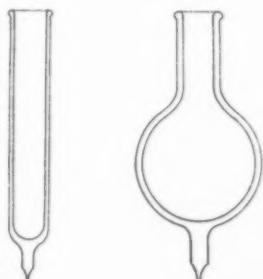


FIG. 2.—LIQUID AIR CONTAINERS.

cycle as "make-up" is supplied by the low-pressure air pump H, which draws it from the atmosphere, compresses it to a pressure of 4 atmospheres and delivers it to the low-pressure cylinder G of the high pressure air pump, where it is compressed to a pressure of 50 atmospheres. At this pressure it enters the high-pressure cylinder, together with the partly expanded air from the heat interchanger, as described above.

Low-pressure compressors are not usually supplied with the

of compression by means of chloride of calcium placed in the dryer supplied with the machine.

If the liquid air is to be used for the production of pure oxygen and pure nitrogen it is subjected to a process of rectification which is very similar to the process employed in spirit distilleries for the separation of alcohol and water. In this way it is possible to get oxygen 95 per cent pure, and if the output is reduced by 10 or 20 per cent the purity of the oxygen

may be brought up to as much as 98 or 99 per cent. The chief advantages of this method of producing pure oxygen are claimed to be low expenses, simplicity and safety in work, and the freedom of the oxygen from water vapor, chlorine, etc. The residual gases entirely consist of the ordinary nitrogen constituents of the atmosphere.

An interesting application of nitrogen produced from air in this way is in the production of calcium cyanamide. Five Linde plants are already at work in Europe on a very ex-

FIG. 3.—WORKS OF THE LINDE AIR PRODUCTS CO.

smaller sizes of air-liquefying plants, the lower pressure of the cycle being in such cases maintained at 20 atmospheres and the low-pressure cylinder G drawing the "make-up" air direct from the atmosphere.

Regulation of the several pressures is performed with the aid of pressure gauges by means of regulating valves in the heat interchanger. Safety valves are provided to prevent the maximum pressures being exceeded.

In electric-furnace operations when electric energy is expensive it is advantageous to preheat the charge or to start at once with a molten charge so as to produce only the highest temperatures from electrical energy, in order to save in the consumption of the expensive electrical energy. In the liquefaction of air where the object is to get a very low temperature it is advantageous in quite an analogous way to pre-cool the air. For this purpose a fore-cooler is provided by means of which the compressed air is reduced in temperature to 5° or 10° above zero Fahrenheit, by filling the receptacle provided for the purpose with a suitable freezing mixture, such as ice and salt. This is practical in smaller illustrations.

On the other hand, with larger installations, the preliminary cooling of the air is preferably brought about by a small belt-driven refrigerating machine on the ammonia compression system. The adoption of fore-cooling is advisable in all cases, but especially when the cost of power is an item of great importance.

Between the compressor and the fore-cooler, apparatus is provided for separating water from the compressed air. This apparatus is provided with a suitable drain cock. Further extraction of the aqueous vapors from the compressed air with the smaller installations is performed in the fore-cooler. In larger plants the drying process is effected after the last stage

tensive scale for this purpose alone, whilst other and still larger installations are now in course of construction, so that the industry appears to be already well established. It will be remembered that for the production of cyanamide, calcium carbide is treated in a nitrogen atmosphere at an elevated temperature. It is, therefore, necessary to first get the nitrogen from air. The question then comes up what to do with the oxygen, and while there are, of course, many applications like its use in blow-pipes, etc., the interesting suggestion has been made to use the oxygen for enriching atmospheric air in oxygen and then to treat the latter by electric arc discharges to produce nitrogen oxides for the subsequent manufacture

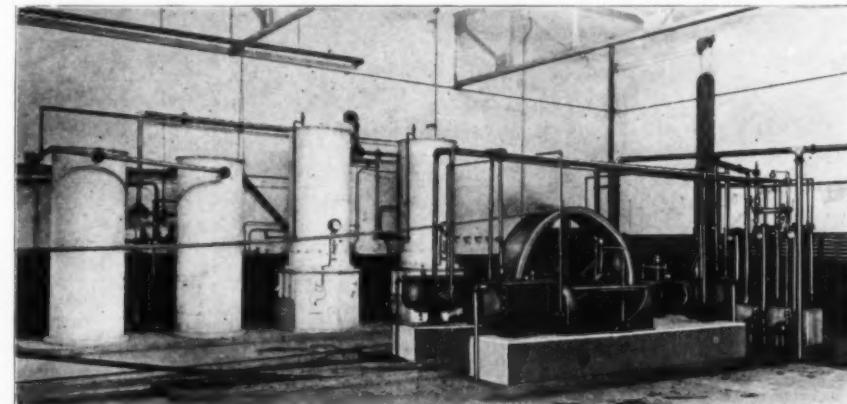
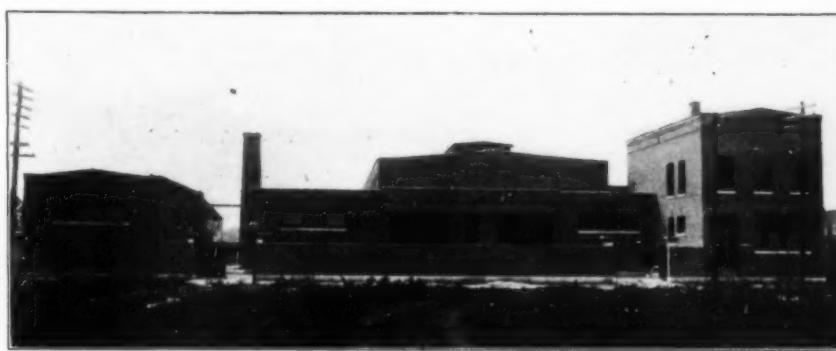


FIG. 4.—PART OF MAIN ENGINE ROOM, SHOWING THE FOUR-STAGE AIR COMPRESSOR, THE TWO FORE-COOLERS AND THE TWO INTERCHANGERS.

of nitric acid and nitrates. In this way the two methods which have so far been found practical for the fixation of atmospheric nitrogen would work side by side; the nitrogen obtained from the liquid air would be used in the calcium cyanamide manufacture and the oxygen would be used in the nitric acid manufacture.

Altogether, about 100 liquid air plants on Dr. Linde's system have already been supplied, of which nearly half are employed either for the production of oxygen or of nitrogen in the pure state, or of both.

Of course, liquid air is useful for many other purposes, especially for all researches or processes in which extremely low temperatures are necessary, since liquid air forms perhaps the most convenient agent for the production and maintenance of such temperatures. Liquid air is also used in surgery, particularly in treatment of certain affections of the skin.

Liquid air boils at atmospheric pressure at 312° F. As the more volatile nitrogen evaporates the color of the liquid assumes a bluish tinge, the color of liquid oxygen. In the liquid state, air occupies $1/800$ of the space occupied by the same weight of air in the gaseous form at normal temperature and atmospheric pressure.

Vacuum vessels are necessary for the storage of liquid air, oxygen and other gases which only liquefy at low temperatures. Such vessels are generally constructed either cylindrical or globular in shape. As shown in Fig. 2 they consist of two glass vessels, one enclosed inside the other and united at the neck. The space between the two vessels is thoroughly exhausted and sealed under a high permanent vacuum. Liquid stored in a vacuum vessel of this construction is very perfectly insulated from the effect of external heat and evaporates slowly.

Approximately the rate of evaporation of liquid air in vacuum vessels of this construction is from 5 per cent to 15 per cent of the original volume per 24 hours, according to the size of the vessel. As evaporation only takes place from the surface of the liquid it is obvious that the size of the vessel is an important factor in determining the length of time for which liquid air can be stored. It should also be noted that if allowed to rest in a quiescent state evaporation progresses much less rapidly than if the vessel containing the liquid air is subject to vibration.

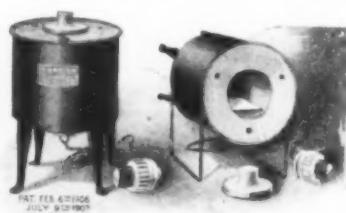
Vacuum vessels of 2 litres capacity and upwards should not be tilted in order to pour out liquid because of the severe strain thus thrown on the glass at the neck of the vessel on account of the contraction which takes place. This is due to the sudden cooling of the glass at the neck when the liquid comes into contact with it. A small hand-pump is a convenient device for emptying vessels without tilting or inverting them.

Electric Muffle Furnace.

The Hoskins Co., of Chicago, who succeeded William Hoskins & Co. in 1905, have commenced the manufacture of the Hoskins electric furnace in addition to the well-known line of Hoskins hydro-carbon blow-pipes and furnaces, which have been on the market since 1880. In this new electric furnace (see also the patent of March on page 413) a great reduction in the cost has been made possible by the use of a patented resistance wire that will not burn or melt at $1,000^{\circ}$ C., and which oxidizes only a very little at this temperature, as a matter of fact, has a melting point above $1,400^{\circ}$ C.

It is a well-known fact that nothing except platinum has heretofore been used for furnace work, and on account of the excessive cost only furnaces of very small capacity have been made. This wire has six times more electrical resistance than platinum wire, and owing to this greater resistance they are enabled to make a furnace without any rheostat or controlling device.

All the resistance wire being wound on the furnace the



ELECTRIC MUFFLE FURNACE.

heat is developed in the furnace chamber, doing useful work instead of part of it being used in heating the air surrounding the rheostat as is usual in platinum wire furnaces. These furnaces can be operated on the ordinary 110-volt electric light circuit, either alternating or direct, for the smaller laboratory sizes.

The same company is also about to put on the market a special electric resistance furnace for alternating current only, that will melt anything from lead to platinum.

These new furnaces will be applicable to every variety of melting and heating work, and at the low price at which they are sold should fill a demand for an electric resistance furnace large enough for all commercial melting operations up to 100 pounds capacity. We also understand the company is prepared to produce electric heating devices of any kind.

Electric Annealing and Hardening Furnace.

On pages 365 and 514 of our Vol. IV. we noticed an electric furnace for annealing and hardening tool steel. Its construction is of great simplicity. Two iron plates at the opposite ends of a vessel filled with a fused salt (barium chloride being mostly used) are connected to an alternating-current transformer. The Joulean effect of the current keeps the bath molten, and by regulation of the current it is easy to adjust the temperature very exactly and quickly. The tools to be hardened are placed within the fused salt. A furnace of this type, which is controlled jointly by the Allgemeine Elektricitäts Gesellschaft, of Berlin, and by the General Electric Co., of this country, was shown in Mr. C. J. Russell's electric furnace exhibit at the last Philadelphia meeting of the American Electrochemical Society, as noticed on page 233 of our June issue.

In an experimental lecture recently held by Mr. L. M. Cohn before the Vienna Electrical Society, some interesting figures as to cost were given. Comparative tests were made on the cost of hardening milling cutters in a gas furnace of American make and in an electric furnace of the above type. In the gas furnace several cutters could be hardened at the same time, while the electric furnace, which was available, was of such a size that only one cutter could be placed in it. Nevertheless, the hardening of 100 cutters required 50 hours in the gas furnace and only 10 hours in the electric furnace. This is simply due to the fact that the temperature in the electric furnace can be adjusted quickly and easily and is always under absolute control.

The cutters were preheated to about 400° and then heated to $1,150^{\circ}$ C. and then cooled. The total cost for the gas furnace was

350 cubic meters of gas.....	\$10.81
Power for blowing.....	1.25
Wages for 50 hours at 17.5 cents.....	8.75
 Total	 \$20.81

The total cost for the electric furnace was

200-kw. hours at 2.5 cents.....	\$5.00
Coke for preheating25
Wages for 10 hours at 17.5 cents.....	1.75
Fresh barium chloride filled in.....	.14

Total	\$7.14
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This shows that under European conditions the electric furnace was very considerably cheaper than the gas furnace. It is true the price charged for gas in this comparison is somewhat high and the price of electrical energy is somewhat low. But the decisive element—which would be even of much greater importance in this country—is the saving in time and the corresponding saving in wages.

Alloys for Steel Manufacture.

Several new alloys for steel works and foundries have been placed on the market by the firm of Hermann & Essing, in Cologne, Germany. One is a high-percentage ferro-manganese, refined so as to be low in carbon. Its average analysis is 88 to 92 per cent Mn, 4 to 6 per cent Fe, 1.5 to 2.5 per cent C.

Another new alloy is refined silico-manganese, which is stated to have the advantages of great purity and high efficiency with low weight, and its reducing power is said to be about three times that of ferro-manganese. The average analysis of this alloy is 68 to 70 per cent Mn, 27 to 30 per cent Si, 2 to 3 per cent Fe, 0.1 to 0.2 per cent C and traces of phosphorus and silver. This alloy is specially suitable for steel refining. It represents an energetic reducing agent. If used in moderate quantities, that is, in proportions corresponding to the degree of oxidation of the bath, the alloy will be almost completely oxidized, forming a manganese silicate, which floats on the surface of the bath. Should any unoxidized manganese or silicon remain in the bath this could be only in very small quantities, which would not be deleterious.

Under these conditions this alloy is suitable for producing a very homogeneous very-low-carbon steel containing very little manganese, free from pipes and blow-holes, that is, soft and very soft sorts of steel, including the manufacture of castings free from blow-holes. By proper addition of carbon to this steel, which contains only a small amount of manganese, hard and very hard steels rich in carbon may be made, and their quality will be much superior to steel containing greater quantities of manganese.

Ferro-aluminium is a very useful alloy for steel and iron foundries, since the aluminium removes all impurities which are deleterious to the quality of iron and steel. The melting point is lowered by an addition of aluminium. The high temperature which is required to melt wrought iron makes it impossible to get solid strong castings. An addition of about 3 per cent ferro-aluminium overcomes this disadvantage, since the melting point is thereby lowered so much that overheating of the wrought iron cannot take place. The tensile strength of the iron is also increased by the addition of ferro-aluminium. The high fluidity of iron treated by this method permits a quick and easy escape of the gases, so that a dense homogeneous casting is obtained. An addition of 0.3 to 5 per cent of a 10 per cent ferro-aluminium is generally used.

Notes.

American Electrochemical Society.—At the meeting of the Board of Directors, held in Philadelphia on July 31, the following gentlemen were elected members of the Society: Franz Roessler, manufacturing chemist, Perth Amboy, N. J.; Eugene Haanel, Ph. D., director of mines, Department of Mines, Ottawa, Can.; L. D. Vorce, superintendent Pennsylvania Salt Manufacturing Co., Wyandotte, Mich.; Herschel C. Parker, professor of physics, Columbia University, New York City; John W. Brown, Ph. D., director research and battery laboratory, National Carbon Co., Cleveland, Ohio; John G. Kremers, electrical engineer and chemist, the Wisconsin Sugar Co., Menomonee Falls, Wis. At the meeting of the Board, held in New York City on Aug. 31, the following gentlemen were elected members: Remo Catani, electrical engineer, Société Elba, Portoferraio, Elba, Italy; William Acheson Smith, vice-president, International Acheson Graphite Co., Niagara Falls, N. Y.; Albert E. Greene, electrochemist, Noble Electric Steel Co., Héroult-on-the-Pit, Baird, Shasta County, Cal.; Hy. L. Kohler, chemist, Scullion Gallagher Iron & Steel Co., St. Louis, Mo.; Horace M. Engle, technical director, the Southern Exploration Co., Terry Building, Roanoke, Va.; Louis Liebmann, Ph. D., electric furnace engineer, Frankfort-on-the-Main, Germany.

Society of Chemical Industry.—The season of the New York Section of the Society of Chemical Industry will be opened by a meeting on Oct. 25, and meetings will be continued monthly, on the third Friday after the first Monday of every month. All the meetings will be held in the Chemists' Club, and will be preceded, as usual, by an informal dinner.

American Peat Association.—A meeting has been called, to be held on Oct. 23 to 26, at the Jamestown Exposition, to consider an organization of those interested in the development of American peat and swamp lands. The United States Geological Survey has established a fuel-testing plant at the Exposition, where peat and products brought together for examination and comparison will be on exhibition. A peat exhibit will also be made in the Mines and Metallurgy Building. The temporary secretary and treasurer of the proposed association is Mr. Julius Bordollo, Kingsbridge, New York City.

Electrometallurgy at Columbia.—The lectures in electrometallurgy at Columbia University have been somewhat extended, Dr. Edward F. Kern (who was formerly connected with Mr. Anson G. Betts) giving this course. A laboratory of electrometallurgy has also been established under Dr. Kern at the School of Mines. Besides the apparatus for electric smelting, refining and testing already owned, the following has been added: Six 144-amp. hour "Bijur high-duty" storage cells, switchboard for connecting these in any desired combination to give current of 10 to 100 amps. at 2 to 12 volts, four Weston standard ammeters for 5 to 50 amps. capacity, and two voltmeters of varying delicacy, rheostats, etc. Current up to 500 amps. at 220 volts can be drawn from the university power circuit. To the metallographic laboratories have been added one Chatelier and six Leitz microscopes for examination and photo-micrography, desk galvanometers and couples for pyrometry, a Wanner and a Féry optical pyrometer, a recording thermoelectric pyrometer, standard thermocouples for checking and calibrating pyrometers. Sauveur specimen cabinet, polishing and emery wheels, etc. Two complete experimental cyanide plants have been installed. Dr. Kern has investigated the electrolysis of metallic sulphides in fused electrolytes, the electrolytic refining of iron, the electrolytic treatment of lead-zinc ores for the recovery of their metallic content and the production of copper-vanadium alloys.

Standard Symbols for Wiring Plans.—The September issue of *The National Electrical Contractor* contains the revised set of standard symbols for wiring plans, as adopted and recommended by the National Electrical Contractors Association of the United States and the American Institute of Architects.

Technical Publicity Association.—At the first meeting of this season, Messrs. N. W. Gage and B. Phillips spoke on the subject of mailing lists.

Tube Mills.—Mr. Max F. Abbé, president of the Abbé Engineering Co., New York, has just returned from a five months' trip in Europe. He visited England, Belgium, Germany and France. In several of the countries he made contracts for the manufacture of his tube mills and linings under various patents that he owns. In Germany he made a contract with the Fried. Krupp Aktiengesellschaft Grusonwerk, at Magdeburg-Buckau, for the building in the United States of their celebrated Excelsior Mills, of which the Krupp people have sold 30,000 in various parts of the world. The Abbé Engineering Co. will be ready within a month to supply the trade with mills of this type.

Assayers' Supplies.—We have received from the Denver Fire Clay Co., of Denver, Col., their illustrated 1907 catalog of assayers' and chemists' supplies. It is a volume of 350 pages, covering the following five departments: Chemists' and assayers' laboratory supplies, special chemical apparatus for analytical work, outfits for assayers and prospectors, school sets of chemical apparatus, collections of minerals, models, etc., fire-brick, tile and fire-clay material, chemicals and reagents.

Alternator Construction.—A motion for preliminary injunction was brought in the United States Circuit Court for the Middle District of Tennessee by the General Electric Co. against the city of Nashville, Tenn., to restrain the city from the further use of some alternating-current generators manufactured by the Bullock Electric Manufacturing Co., on account of the construction of the laminated pole pieces attached to the revolving field spider. Judge Clark has issued the injunction but allowed the city of Nashville sixty days in which to change the pole pieces or to withdraw the machines from use entirely.

Steam Specialties.—The increasing demand for Powell steam engineering specialties makes an enlargement of the plant of the William Powell Co. a necessity. Plans are being prepared to erect buildings on ground, 37 x 200 feet, recently acquired by them and to increase their power plant by 200 hp.

Mr. Henry M. Huxley has resigned from the manager's staff of the Worcester district of the American Steel & Wire Co., to become assistant general manager of the Duplex Metals Co., manufacturers of Monnot copper-clad wire and sheets. Mr. Huxley will be located at 208 Fifth Avenue, New York.

Clay Products in 1906.—The United States Geological Survey has just issued a statistical table of the different clay products of the United States in 1906. The figures are given for common brick, vitrified paving brick or block, front brick, etc. The production of fire-brick amounted to 770,839,000, valued at \$14,206,868 (against 679,971,000, valued at \$12,735,404 in 1905). The value of the total brick and tile produced in 1906 is given as \$129,591,838, the total value of pottery as \$31,440,884, the sum of both being \$161,032,722.

Brass and Iron Specialties.—One of the most complete and modern lines of brass and iron specialties for engine and boiler rooms, etc., is shown in the catalog of the William Powell Co., of Cincinnati, which has recently been issued. This catalog presents their line in a most complete and practical manner, giving dimensions of every article for which a dimension may be required, and explaining in detail the merits of their well-known specialties. A valuable series of tables and rules is bound in with the catalog, giving in a concise form information that every engineer and shop manager requires in his daily practice. A copy may be had for the asking.

Wet Process for Gold, Silver and Copper Ores.—Bulletin No. 4 of the Hendryx Electro Cyanide Co. describes first the Hendryx process for treating gold and silver ores. The special features are the following apparatus designed by Mr. Hendryx: The agitator in which the gold and silver from the ore pulp are dissolved in a cyanide solution; the decanting filter where the solutions are recovered and the tailings washed, and the zinc-dust precipitator. These apparatus are described and illustrated. For treating oxides and carbonates of copper, the copper is leached out in the agitator by means of sulphuric acid, and the copper is recovered in a special precipitator as cement copper, being precipitated by means of scrap iron. For treating copper sulphide ores the Hendryx process is as follows: The ore is ground and introduced into the agitator and sulphuric acid added. In this case the agitator is provided with insoluble electrodes. When the current is turned on the iron in the ore (which is nearly always naturally associated in sufficient quantity with the copper sulphide ores) is converted into ferric salt, which dissolves the copper. The copper is deposited on the cathodes, the iron is oxidized and regenerated as ferric salt (as in the old Siemens-Halske process). The solutions are then passed through electrolytic precipitating boxes. Ores containing gold and silver and copper are given a double treatment, first removing the soluble salts of copper and then cyaniding the gold and silver.

Stamp Milling Machinery.—Catalog 6-C of the Colorado Iron Works Co., of Denver, Col., contains on 72 pages illustrated descriptions of the various apparatus used in the treatment of gold ores by stamp milling and amalgamation. As is

usual with bulletins issued by this company the little book is more than a trade catalog and contains as introductory article a well-written and concise exposition of the fundamental principles of treating gold ores by plate amalgamation.

Copper and Silver-Lead Ores.—Catalog No. 6 of the Power & Mining Machinery Co., of Cudahy, Wis., contains brief illustrated descriptions of the various pieces of machinery, furnaces, etc., used in roasting, smelting and refining of copper and silver-lead ores. Twenty-six pages are devoted to descriptions of crushing machinery, 14 to roasting furnaces, 30 to smelting furnaces, 11 to converters, besides descriptions of accessory machinery and notes on copper and lead refining and the use of producer gas in the power plant.

Digest of U. S. Patents.

Compiled by Byrnes & Townsend, Patent Lawyers, National Union Building, Washington, D. C.

CALCIUM CARBIDE (Continued.)

No. 594,740, Nov. 30, 1897, Herman L. Hartenstein, of Bellaire, Ohio.

Calcines limestone mixed with coke by forcing air upward through it. The hot lime is discharged from the lower end of the calcining kiln into an electric furnace consisting of a chamber having several rows of superposed openings in its side walls. Four vertical electrodes are arranged at the sides of the smelting chamber, with lining sections between them. Finely pulverized coke is blown through a main by illuminating gas under high pressure, and thence through multi-perforated tuyeres arranged in the side wall openings into the interstices of the heated lime. Electric current passes between the electrodes and through the charge in the form of "an almost infinite number of arcs generating heat and rendering the mass highly incandescent." The pulverized coke forced into the lime acts as a more or less perfect conductor. The molten "carbureted limestone" is withdrawn through a tap hole at the base. The hot gases pass upward into the lime kiln. Two electric smelting chambers are provided, each mounted on wheels. These are employed alternately, to permit repairs.

No. 595,712, Dec. 21, 1897, James Ellicott Hewes, of Philadelphia, Pa.

An electric furnace of the pot type provided with means for reciprocating the depending electrode in order to stoke the charge into the arc or current path. It is alleged that the carbide produced under continuous stoking is largely amorphous, containing at most a few crystals; and that while such amorphous carbide is less pure than ordinary crystalline carbide, the gas yield per horsepower-hour is not inferior, as the stoking increases the output per unit of power. The specific furnace shown comprises a brick receptacle having a loose lining of lime and carbon and a metal hearth constituting one electrode. The other electrode depends centrally above the hearth, is adjustable as to position, and is in operation reciprocated by means of a cam or eccentric.

Nos. 596,704, 596,705, 596,749, Jan. 4, 1898, Herman L. Hartenstein, of Bellaire, Ohio.

Proposes to use blast furnace slag as a raw material for the production of carbides. A suitable slag for the purpose is stated to contain 50-55 per cent of lime, 25-28 per cent silica and 16-18 per cent alumina. The product is stated to be a mixture of the carbon compounds of calcium, silicon and aluminum. The slag is introduced molten into a special form of converter mounted on trunnions and provided with tuyeres and with carbon electrodes, and is then impregnated with a suitable proportion of finely divided carbonaceous material, as coke, introduced through the tuyeres by means of a current of reducing gas, it being alleged that the gas increases the temperature of the molten slag. After a uniform mixture is secured the electric current is passed between the electrodes to effect the conversion into carbide.

NEW BOOKS.

THE METALLURGY OF THE COMMON METALS.—By Leonard S. Austin. 406 pages; illustrated with half-tones, drawings and diagrams of machinery and the appliances used in modern metallurgical practice. Bound in cloth. Price, \$4.00. San Francisco, Cal.: Mining and Scientific Press.

BLAST FURNACE CALCULATIONS and tables for furnace managers and engineers, containing rules and formulas for finding the dimensions and output capacity of any furnace, as well as the regular outfit of stoves, heating surface, volume of air, tuyere area, etc., per ton of iron per day of 24 hours.—By John L. Stevenson. 44 pages of reading matter, tables and diagrams, and 116 pages containing forms for recording results of operations. Bound in leather. Price, \$2.00 net. New York: D. Van Nostrand Co.

THE FIRE ASSAY OF GOLD, SILVER AND LEAD IN ORES AND METALLURGICAL PRODUCTS.—By Leonard S. Austin. First edition. 88 pages; 42 illustrations. Bound in cloth. Price, \$1.00. San Francisco, Cal.: Mining and Scientific Press.

DREDGING FOR GOLD IN CALIFORNIA.—By D'Arcy Weatherbe. First edition. 217 pages; 103 illustrations. Bound in cloth. Price, \$4.00. San Francisco, Cal.: Mining and Scientific Press.

TEXTBOOK OF ORGANIC CHEMISTRY.—By A. F. Holleman, Ph. D. Translated from the third Dutch edition by A. Jamieson Walker, Ph. D., assisted by Owen E. Mott, Ph. D., with the co-operation of the author. Second English edition, rewritten. 589 pages; 83 illustrations. Bound in cloth. Price, \$2.50. New York: John Wiley & Sons. London: Chapman & Hall, Ltd.

ORGANIC CHEMISTRY, including certain portions of physical chemistry; for medical, pharmaceutical and biological students; with practical exercises.—By H. D. Haskins, M. D., and J. J. R. MacLeod. 378 pages; illustrated. Bound in cloth. Price, \$2.00 net. New York: John Wiley & Sons.

LABORATORY OUTLINE OF GENERAL CHEMISTRY.—By Alex. Smith. Third revised edition in collaboration with W. J. Hale. Illustrated. Bound in cloth. New York: Century Co.

A TEXTBOOK OF PHYSIOLOGICAL CHEMISTRY FOR STUDENTS AND PRACTITIONERS OF MEDICINE. Third revised edition.—By E. C. Simon. 490 pages. Bound in cloth. Price, \$3.25. Philadelphia: Lea Brothers & Co.

MERCK'S 1907 INDEX. Third edition. An encyclopedia for the chemist, pharmacist and physician, stating the names and synonyms, source of origin, chemical nature and formulas, physical form, appearance and properties, melting and boiling points, solubilities, specific gravities and methods of testing, physiological effects, therapeutic uses, modes of administration and application, ordinary and maximum doses, incompatibles, antidotes, special cautions, hints on keeping and handling, etc., of the chemicals and drugs used in chemistry, medicine and the arts. 472 pages. Bound in cloth. New York: Merck & Co.

PRACTICAL TEST BOOK OF CHEMISTRY. Including specific tests and tests for purity.—By Dabney J. Palmer, M. D. 200 pages. Bound in cloth. Price, \$1.00 net. New York: John Wiley & Sons.

LABORATORY WORK IN ELECTRICAL ENGINEERING. (Preliminary grade.)—By J. Roberts, Jr. Illustrated by diagrams and tables. Price, \$2.00 net. New York: Van Nostrand Co.

TREATISE ON ELECTRIC LAW. Law governing all electric corporations.—By Jos. Asbury and Howard C. Joyce. Second edition in two volumes. Bound in cloth. Price, \$12.75. New York City: Banks Law Publishing Co.

MECHANICAL ENGINEER'S REFERENCE BOOK. Third edition, revised and enlarged.—By Harrison S. Suplee. Illustrated by drawings and tables. Limp leather binding. Price, \$5.00; with thumb index, \$5.50 net. Philadelphia: J. B. Lippincott Co.

TEXTBOOK OF MECHANICS. Vol. II. Kinematics and kinetics. By Adolphe L. Martin. 218 pages; illustrated. Bound in cloth. Price, \$1.50 net. New York: John Wiley & Sons.

SHAFT SINKING UNDER DIFFICULT CONDITIONS.—By J. Riemer. Translated from the German by C. R. Corning and Rob Peele. 189 pages; illustrated. Bound in cloth. Price, \$3.00. New York: John Wiley & Sons.

Department of the Interior.—United States Geological Survey. Advance Chapters from Mineral resources during 1906:

The Production of Talc and Soapstone in 1906. By Arthur J. Collier. 7 pages.

The Production of Quartz (Flint) and Feldspar in 1906. By Edson S. Bastin. 22 pages.

The Production of Chromite or Chromic Iron Ore in 1906. By Arthur J. Collier. 4 pages.

The Production of Precious Stones in 1906. By Douglas B. Sterrett. 44 pages.

The Cement Industry in the United States in 1906. By Edwin C. Eckel (advances in cement technology) and L. L. Kimball (statistics).

BOOK REVIEWS.

THE MINERAL INDUSTRY DURING 1906.—Its Statistics, Technology and Trade. Vol. XV. Edited by Walter Renton Ingalls. 954 pages; illustrated. Bound in cloth. Price, \$5.00. New York: Hill Publishing Co.

We have received Vol. XV. of the *Mineral Industry*, the great annual of the mining, chemical and metallurgical industry founded by the late Richard P. Rothwell.

This book has become such a standard and is so representative of the progress of the great source of elemental wealth in this age of metal, that there is little left to the reviewer save praise for the enterprise and sagacity of the publisher and editor. It is a credit to the American publishing trade. We have the same line of distinguished experts, as Prof. James Douglass, of the Phelps-Dodge interests, on copper in Arizona; W. R. Ingalls, the editor on zinc; Prof. R. H. Richards, on ore dressing; Prof. J. W. Richards, on aluminium, and Prof. L. S. Austin, on progress of the metallurgy of copper. Prof. J. F. Kemp is represented with a review of the literature on ore deposits, in addition to articles by many other engineers, each noted for excellence in their respective specialties.

The electrochemical industry is represented by special articles by Mr. F. J. Tone, on carborundum and on silicon; Mr. L. Addicks, on the enlarged electrolytic copper plant of the United States Metals Refining Co., at Chrome, N. J.; Mr. A. J. Lotka, on synthetic nitrates, giving a short account of the "flaming-arc furnace" at Notodden, Norway. All things considered, the present volume falls little short of the standard set by the eminent founder.

* * * *

DREDGING FOR GOLD IN CALIFORNIA. By D'Arcy Weatherbe. 8vo. 217 pages; 103 illustrations. Price, \$4.00. San Francisco: Mining and Scientific Press.

A very attractive monograph, the best we have seen on this important industry. Its value is heightened greatly by the excellent illustrations, most of them from photographs.

The introduction gives clear ideas of the general problems involved; this is followed by a detailed description of how dredging ground is prospected; then forty pages on the construction of the dredging machines, well illustrated and very complete; then twenty pages on the operation of a dredge, equally well done. The thirty pages on the metallurgy of dredging, describing the screens, tables, sluices and cleaning-up, are full of valuable information from a first-hand authority; they are excellently written and illustrated. Costs are exhaustively handled, and the horticultural question of reclaiming

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the worked-over ground is gone into. It is satisfactory to know, from the aesthetical as well as from the economic standpoint, that eucalyptus grows rapidly on these dumps, or that the unsightly piles can be scraped level and covered with a foot of soil for about \$250 per acre. Since an average profit of nearly \$4,000 per acre is made from working these grounds, it seems quite reasonable that the State should step in and require that no agricultural land be sold, leased or used for dredging purposes without the purchaser, lessor or owner being obligated, by bond or otherwise, to restore the land to a level, soil-covered condition. Such action by the State would stop the wicked desolation of some of the garden spots of the earth now going on unchecked.

The book concludes with a half dozen contributions by others to special sides of the dredging question, completing a most acceptable and valuable addition to the metallurgy of gold.

* * * *

THE FIRE ASSAY OF GOLD, SILVER AND LEAD IN ORES AND METALLURGICAL PRODUCTS. By L. S. Austin, Professor of Metallurgy and Ore Dressing in the Michigan School of Mines. 8vo. 88 pages. Price, \$1.00. San Francisco: The Mining and Scientific Press.

The aim of the author is to present a single system of assaying, adapted for assaying these ores and products in the Rocky Mountain States. This system is called "Austin's Fire Assay."

The directions for sampling are brief and clear. We do not relish the imputation contained in the caution that the assayer should be "especially" careful if he is sent a regularly ground sample to assay, since another assayer can assay a portion of the same sample "as a check on his work." Perhaps it is a failing of human nature to be more careful when you may be checked off by another; but in teaching a man how to work, should we not hold before him the ideal of "best work" without regard to any possibly checking off? Furnaces and tools, crucibles, scorifiers and balances are briefly described. In the description of fluxes and reagents we note nothing new. The general classification of ores is very brief and somewhat vague; we cannot agree, for instance, that blende and pyrite form an "oxidized basic ore," or that galena and pyrite have "a semi-metallic appearance."

The scorification assay and the chemical reactions proceeding in it are described excellently, likewise cupelling and parting. Under the latter item very neat advice is given, to the effect that if less than one-fourth of the alloy is dissolved, to melt up with pure silver and part again. This might have very properly been prefaced by the direction to melt up the alloy button with three times its weight of silver, in the first instance, if it shows any trace of yellow color. The crucible assay is one of the best written chapters in the book, the reactions being explained in detail and the chemical equations given. Roasting, assay of matte, of high-grade silver sulphide, of cyanide solutions, base bullion, precious bullion and blister copper are each very briefly treated, also the assay of a lead ore.

Altogether, with its brief but clear treatment of reliable methods, the book forms a satisfactory introduction to assaying in the limited field intended to be covered.

* * * *

OPEN-HEARTH STEEL CASTINGS. By W. M. Carr. 12mo. 118 pages; 19 illustrations. Price, \$1.50. Cleveland, Ohio: Penton Publishing Co.

It is a very encouraging sign of progress in metallurgical literature when we begin to have monographs, such as this, on a small corner of the metallurgy of iron, written by a competent author who knows at first hand what he is talking about. One man, be he even a Lebedur, cannot be at once a scientific master and a practical man in all parts of the metallurgy of iron, and therefore such comprehensive works as

Ledebur's are always capable of being supplemented by practical monographs such as the one before us.

The style of the writing is brief, crisp and pertinent. Nothing but the bare essentials of present American practice are given, but these are given so clearly and pointedly that no bright American reading the book can fail to take them in at the first reading. The information thus gained will be somewhat scanty and fragmentary, but will form a first-class basis for further study of the subject in a broader way, because it is almost all right as far as it goes.

The chapter on "Materials Used" contains an immense amount of data concerning fuels, pig iron, scrap, refractories, molding materials and tools, for acid and basic practice, compressed into the fewest possible words. The thirteen pages on "Furnace Construction" is very good, many items from the author's experience being valuable information. The short chapter on fuels is not so good; it is impossible to do even brief justice to such a subject in the space taken. The ten pages on the "Manipulation of Acid Furnace Heats" is finely done, as also the similar chapter on basic heats. These twenty pages give a vivid picture of the primary essentials of open-hearth practice. The attempt to compress "Chemical Analyses and Physical Tests" into nine pages is unsatisfactory; it is so condensed that only the expert could digest and use the information it contains—particularly on the chemical side. The relation between composition and physical properties is clearly presented in thirteen pages, with the success of the earlier chapters. The study of blow-holes is very brief and rather indefinite; it should have been double as long, because of the great importance of this topic. The ten pages on "Heat Treatment" gives a satisfactory first idea of the subject; the microphotographs show up too poorly to be of any assistance. Four pages on the use of "Thermit" show that the writer has brought his book thoroughly up to date. The concluding chapter on "Costs" is greatly condensed and gives only elementary ideas on a small plant.

Altogether, in the space taken up there was never before compressed so much useful and accurate information on this subject—and put into such comprehensible and entertaining form.

* * * *

THE ELEMENTS OF CHEMICAL ENGINEERING. By J. Grossmann, M. A., Ph. D., F. I. C., Chemical Engineer and Consulting Chemist in Manchester. With a preface by Sir William Ramsay, K. C. B., F. R. S. 152 pages; 50 illustrations. Price, \$1.50. London: Charles Griffin & Co., Ltd. Philadelphia: J. B. Lippincott Co.

In the preface by Sir William Ramsay it is said that "in Britain there is, for the most part, a gulf fixed between the technical and the scientific chemist." That a similar gulf exists to some extent in this country was claimed in a much discussed paper by Mr. J. B. F. Herreshoff before the New York Section of the American Chemical Society a few years ago. The object of Dr. Grossmann's book is to bridge this gulf, to aid a student in proceeding from the scale of laboratory to that of manufacturing operations.

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The book is highly suggestive and often gives good advice. Thus, to give only one example, "it may be safely stated that although every one has had ample opportunity of watching brick-setters at their work, few will have exercised their powers of observation sufficiently to know exactly how the work should be and is done." A chemical engineer who is called upon to design a plant should know this; he should also have a general knowledge of the principles of iron founding, the coupling of pipes, carpentering, joinery, etc. It seems to us that this little book should be very useful.

* * * * *

MERCK'S 1907 INDEX. Third Edition. An Encyclopedia for the Chemist, Pharmacist and Physician, of the Chemicals and Drugs used in Chemistry, Medicine and the Arts. 472 pages. New York: Merck & Co.

The former editions of *Merck's Index* have become so popular that it is unnecessary to say anything about the general scope and character of the book. The new edition has been brought up to date by adding the newest products, by adopting the latest nomenclature, by consulting the most modern authorities, and, for the Merck products, by verifying the data in their laboratories and works. The Merck products are now indicated by the word Merck after the product.

Furthermore, the crude drugs of commerce have been added, and under each drug the dose of its extracts, tinctures, fluid extract, etc., are given, instead of grouping all extracts, tinctures, etc., together as in the previous editions. No prices are given but comparative values; this is done very cleverly.

The book, which has become indispensable to many chemists, pharmacists and physicians in the past, will undoubtedly gain many new friends. It is sent to users of chemicals and drugs by the authors and publishers for remitting the forwarding charges, which amount to 25 cents in round figures.

